The National Academies of
SCIENCES • ENGINEERING • MEDICINE

TRANSPORTATION RESEARCH BOARD

Hit the Ground Running—Innovative Concrete Pavements in Roundabout Design

December 16, 2021

@NASEMTRB
#TRBwebinar

PDH Certification Information:

- 1.5 Professional Development Hour (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
- Questions? Contact TRBWebinars@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

RCEP

REGISTERED CONTINUING EDUCATION PROGRAM

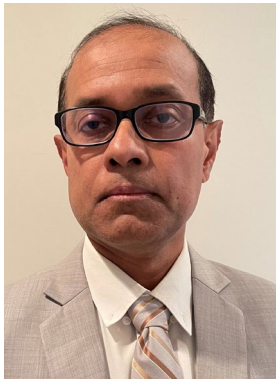
#TRBwebinar

Learning Objectives

1. Identify typical applications for CRCP and PCP on roundabouts
2. Discuss construction and design considerations of CRCP and PCP on roundabouts

Jeffrey Shaw
Jeffrey.shaw@dot.gov
Federal Highway Administration

Shiraz Tayabji
stayabji@gmail.com
Advanced Concrete Pavement Consultancy, LLC



Shabbir Hossain
Shabbir.Hossain@vdot.virginia.gov
Virginia Department of Transportation

Kurt Smith
ksmith@appliedpavement.com
Applied Pavement Technology, Inc.

Today's Program

- Introduction to Roundabouts: Jeff Shaw, FHWA
- CRCP Roundabouts: Shiraz Tayabji, ACPC
- Precast Concrete Pavement Roundabouts: Shiraz Tayabji, ACPC
- Precast Concrete Pavement Roundabouts—A Virginia Case Study: Shabbir Hossain, VDOT

- Part 1 Webinar: https://www.nationalacademies.org/event/11-17-2021/trb-webinar-hit-the-ground-running-designing-roundabouts-with-conventional-pavement

FHWA Tech Briefs on Pavements for

- Tech Brief: Hot-Mixed Asphalt Pavement (HMAP) Roundabouts
- Tech Brief: Jointed Concrete Pavement (JCP) Roundabouts
- Tech Brief: Continuously Reinforced Concrete (CRC) Roundabouts
- Tech Brief: Precast Concrete Pavement (PCP) Roundabouts

https://www.fhwa.dot.gov/pavement/pub_listing.cfm

ZERO IS OUR GOAL

A SAFE SYSTEM IS HOW WE GET THERE

Roundabouts: Paving the Way to Safety

Jeffrey Shaw, P.E. – FHWA Office of Safety

Presented on 12/16/2021 for the

TRB AKP20, AKC20 and AKD80 Committees

Intersection Safety Importance

- Just over **one-quarter** of all traffic related fatalities in the United States are related to intersections
- About **one-half** of all traffic related serious injuries are related to intersections

Innovative/Alternative Intersections

Essential ingredients:

- Improve the way ***people*** move across intersections
- Strategically optimize traffic control
- Deliver “safe mobility”

Source: FHWA

“cho·re·og·ra·phy”

Innovative Intersection Benefits

SAFETY

- Fewer, less severe conflict points
- Speed management potential
- Significant injury reductions

MOBILITY

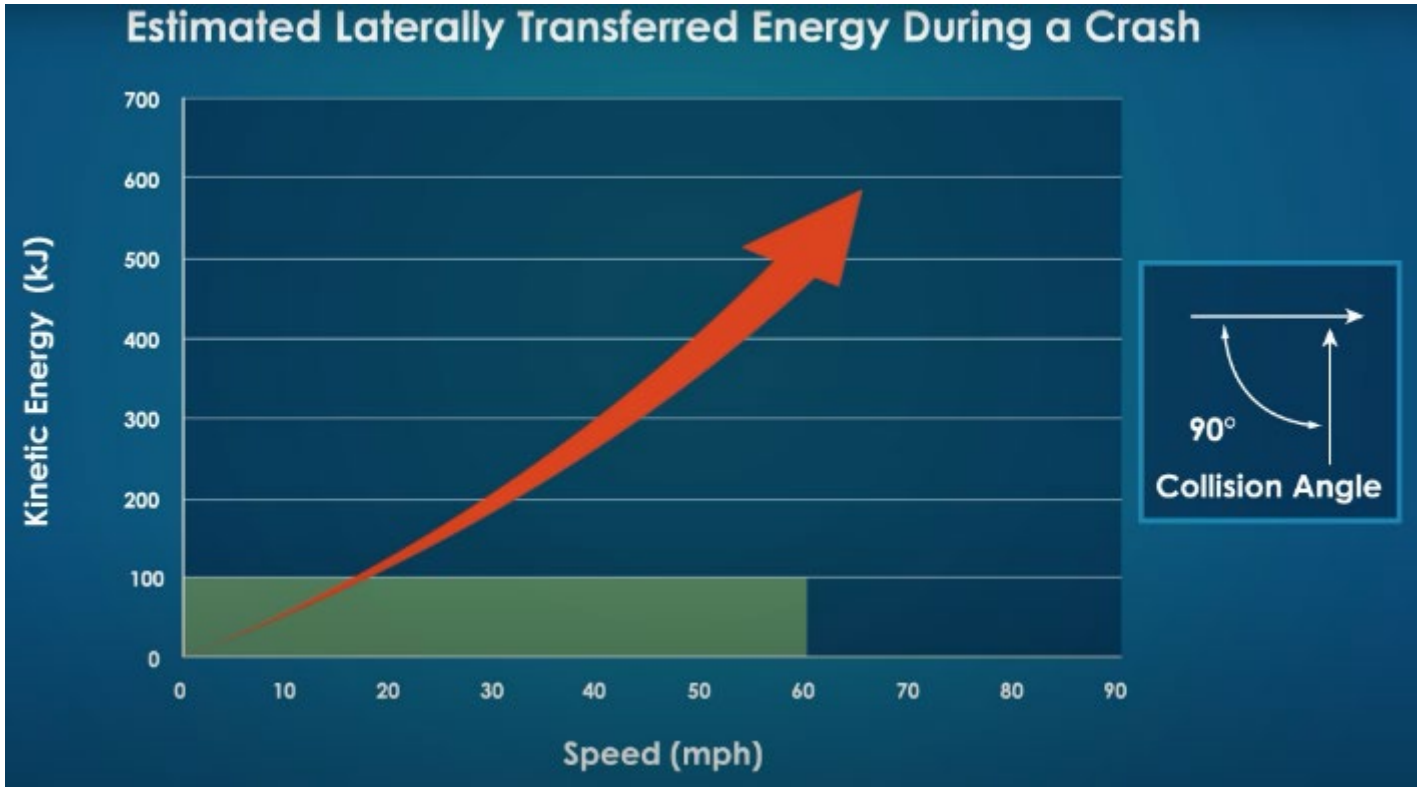
- Shorter trip duration
- Better trip reliability
- Reduced congestion
- Opportunities for walking and biking

VALUE

- Less right-of-way
- Quicker construction
- Decreased costs
- Balanced solutions

The Principles of Safer Intersections

- Eliminate or modify conflict points
- Reduce vehicle speeds
- Manage potential collision angles
- *Kinetic energy management*



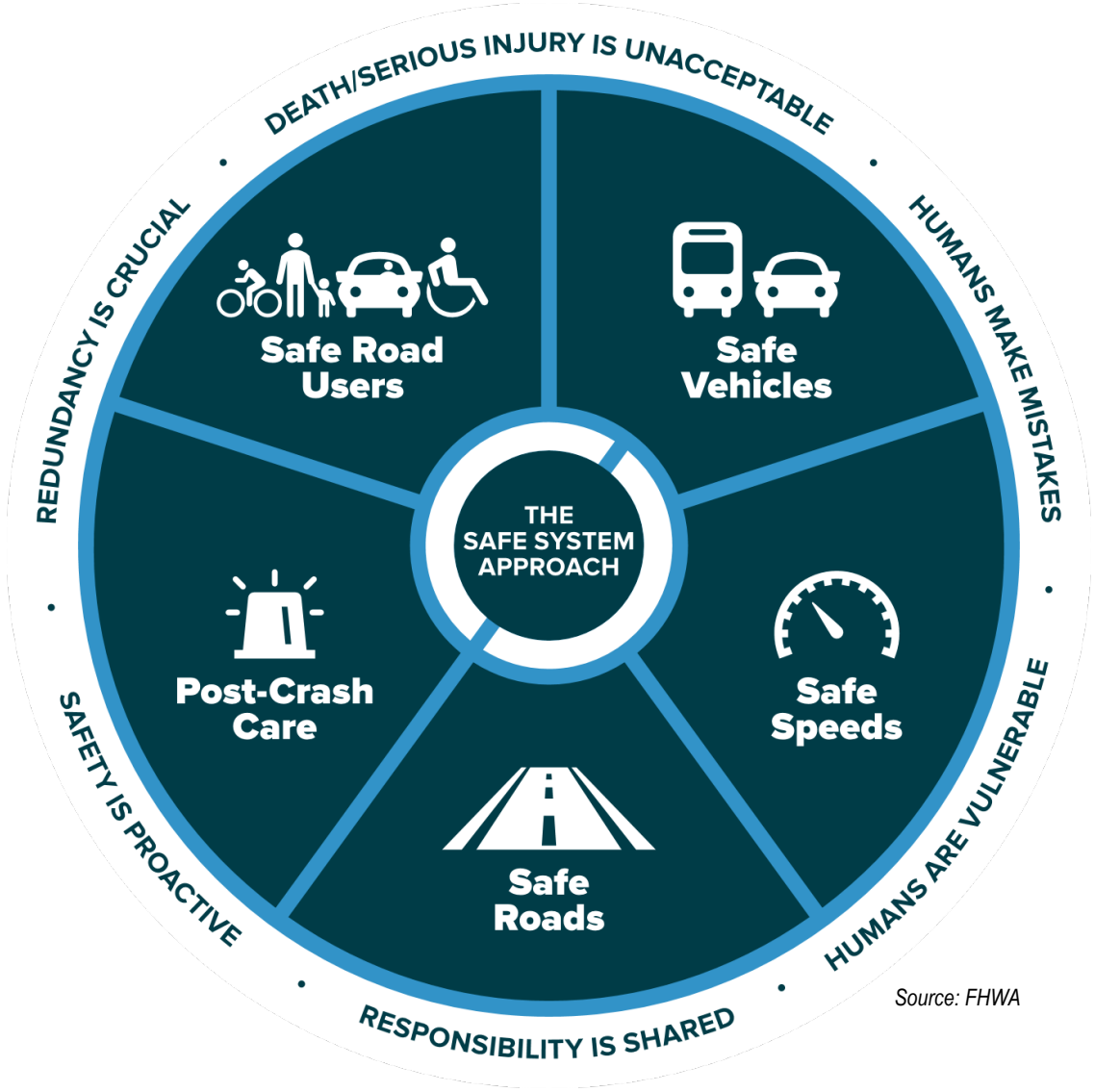
Source: FHWA

A New Paradigm

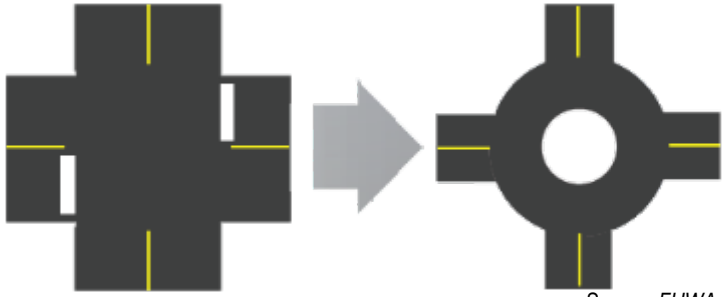
The **Safe System Approach** aims to eliminate fatal and serious injuries for all road users by:

Accommodating human mistakes

Keeping impacts on the human body at tolerable levels



Source: FHWA



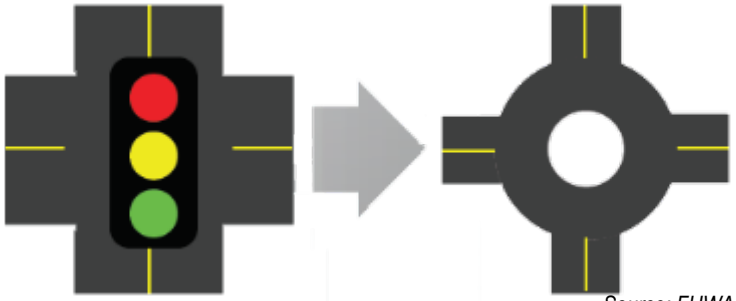
Source: FHWA

Convert a Two-Way Stop-Controlled Intersection to a Roundabout

82%

Reduction in fatal and injury crashes

Source: AASHTO Highway Safety Manual



Source: FHWA

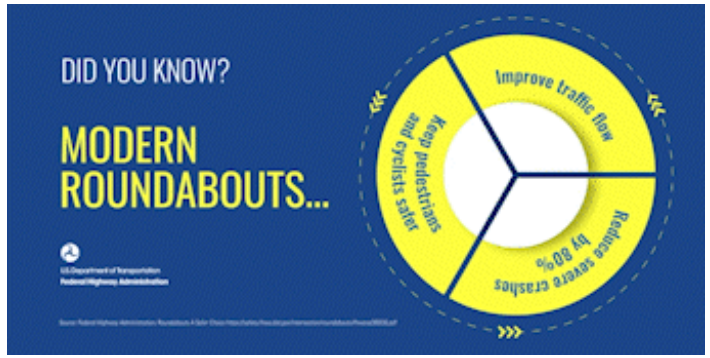
Convert a Signalized Intersection to a Roundabout

78%

Reduction in fatal and injury crashes

Source: AASHTO Highway Safety Manual

Source: FHWA



Source: FHWA

Doubling Down

- Roundabouts have been a Proven Safety Countermeasure since 2008
- Featured in the “Double Down on What Works” pillar of the RTZ Coalition
- Globally recognized as a Safe System solution
- An estimated more than 7,000 now in the U.S.

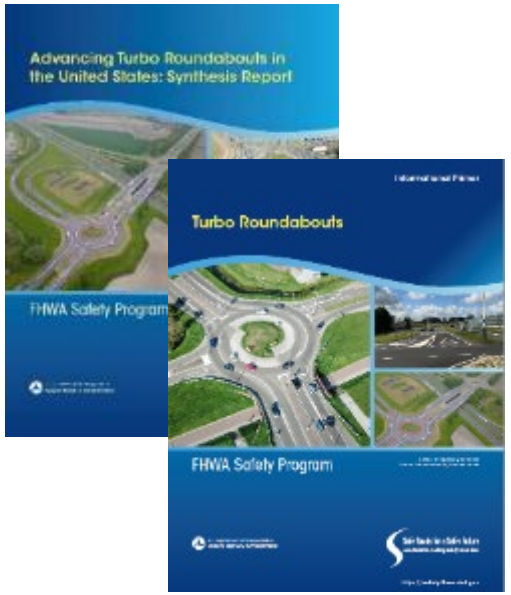
Source: National Safety Council, Road to Zero Coalition

Source: Jeff Shaw, FHWA

*Roundabouts have an **EXCEPTIONAL** ability to substantially reduce fatal and serious injury crashes while still keeping people moving*

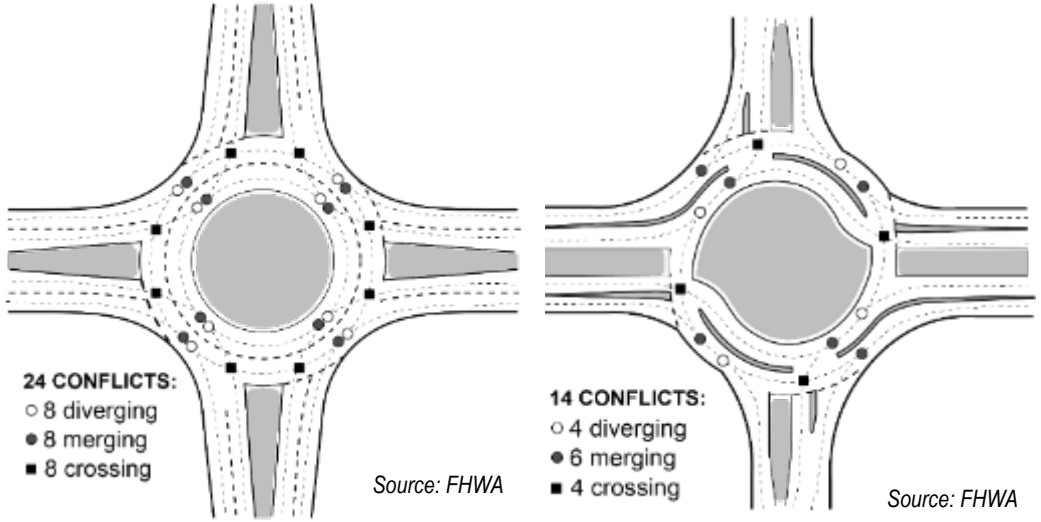
Roundabouts are Adaptable

- May be single lane, multilane, or mini/compact designs
- Emerging multilane design is the “turbo”



Source: FHWA

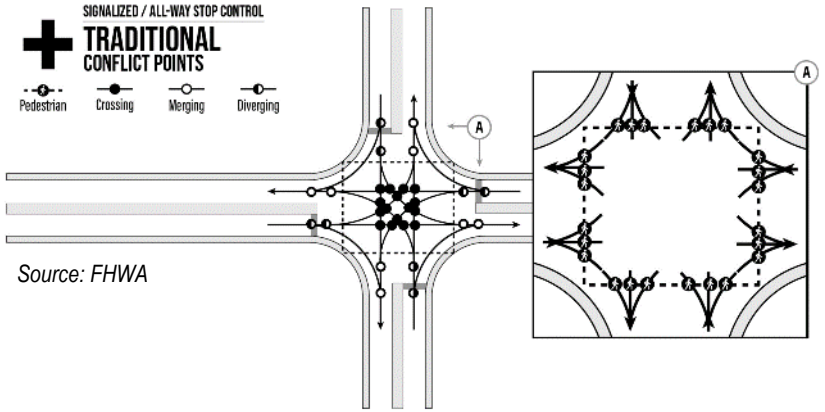
Source: FHWA



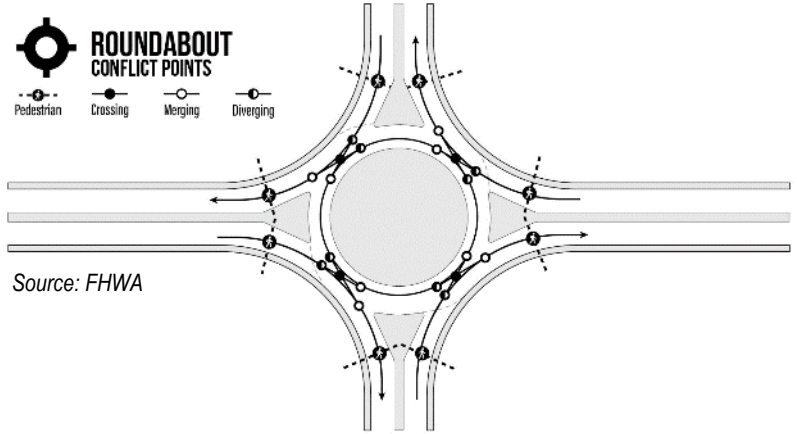
Source: FHWA

Source: FHWA

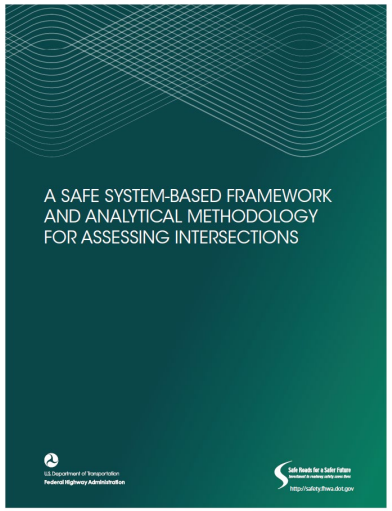
Safe System Intersections



Source: FHWA



Source: FHWA



Source: FHWA

"Built on Innovative Intersection Principles"

1 Number of conflict points of type t

2 Exposure index

3 Severity

5 Nonmotorized Movement Complexity Factor

$$E_t = \sum_{i=1}^{n_t} \left[I_{i,t} * \mathrm{P(FSI)}_{i,t} * L_{1,i,t} * L_{2,i,t} \right]$$

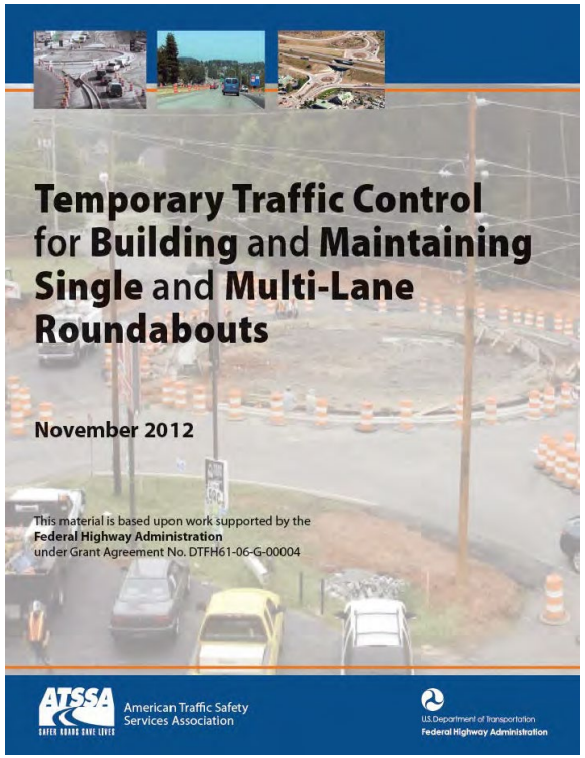
1 Conflict Point Type
t = crossing, merging, diverging, or nonmotorized

4 Conflicting Traffic Complexity Factor

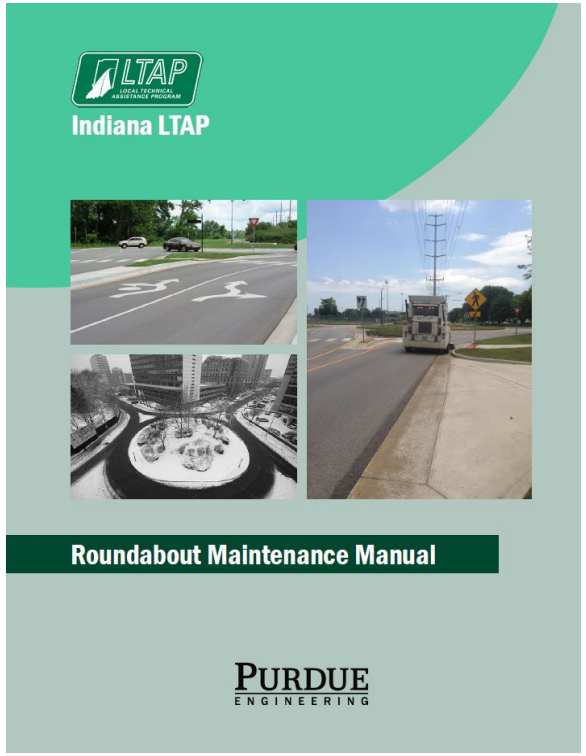
Source: FHWA

Roundabout Construction Information

- Reports on TTC and staging for roundabout construction and maintenance
- Include project examples
- Both can be found at the National Work Zone Safety Information Clearinghouse at https://www.workzonesafety.org/



Source: ATSSA-FHWA



Source: Indiana LTAP

Thank You!

Contact Information:

Jeffrey Shaw, P.E.
FHWA Office of Safety
jeffrey.shaw@dot.gov
(202) 738-7793

https://safety.fhwa.dot.gov/intersection/roundabouts/index.cfm

Continuously Reinforced Concrete Pavement (CRCP) Roundabouts

© 2016 Texas DOT

© 2013 European Concrete Paving Association

Transportation Research Board Webinar

Shiraz Tayabji

U.S. Department of Transportation

Federal Highway Administration

Outline

- CRCP Overview
- CRCP Roundabouts
- Pavement Design Considerations
- Pavement Construction
- Summary

Tech Brief

MARCH 2021 FHWA-HIF-20-081

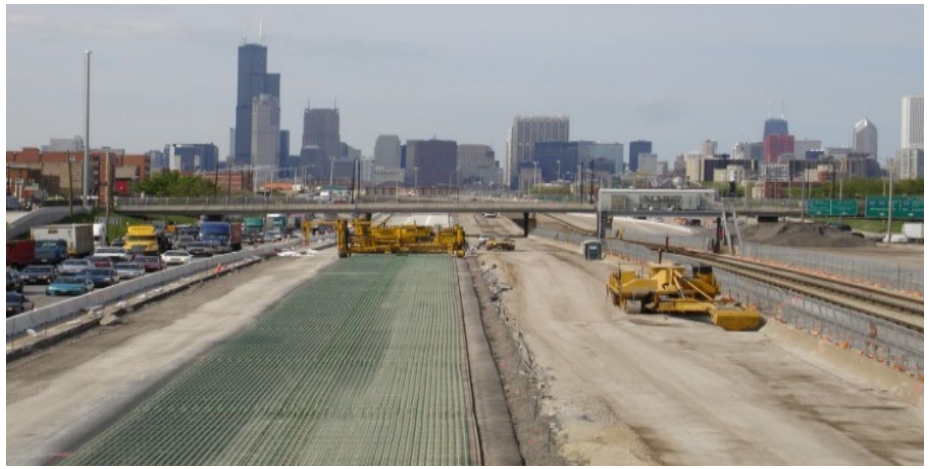
Continuously Reinforced Concrete (CRC) Roundabouts

Except for any statutes or regulations cited, the contents of this presentation do not have the force and effect of law and are not meant to bind the public in any way. This presentation is intended only to provide information to the public regarding existing requirements under the law or agency policies.

Introduction to CRCP

- First introduced in the U.S. in 1921
- Production use in U.S. during 1940s
- Widely used in the U.S. since 1960s
- Over 30,000 lane miles constructed in the U.S.
- Used for primary highways in AR, CA, IL, OK, OR, TX, VA

© Shiraz Tayabji

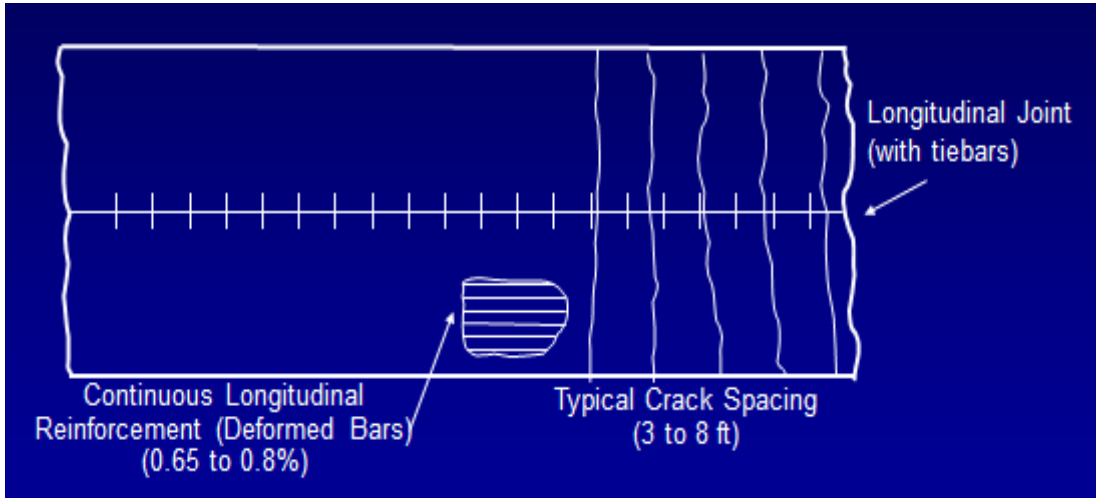


© CRSI

These States use CRCP as pavement of choice for highways with heavy truck traffic

Introduction to CRCP (cont'd)

- CRCP differs from other concrete pavements
  - No transverse joints
  - Continuous longitudinal reinforcement interacts with concrete to produce tight cracks at 3 to 6 ft spacing & then holds cracks tight
  - Amount of steel (0.65 to 0.75%) and slab/base interface determine crack spacing & width
  - CRCP can extend, joint-free, for many miles with breaks provided only at structures
  - Considered a true long-life concrete pavement

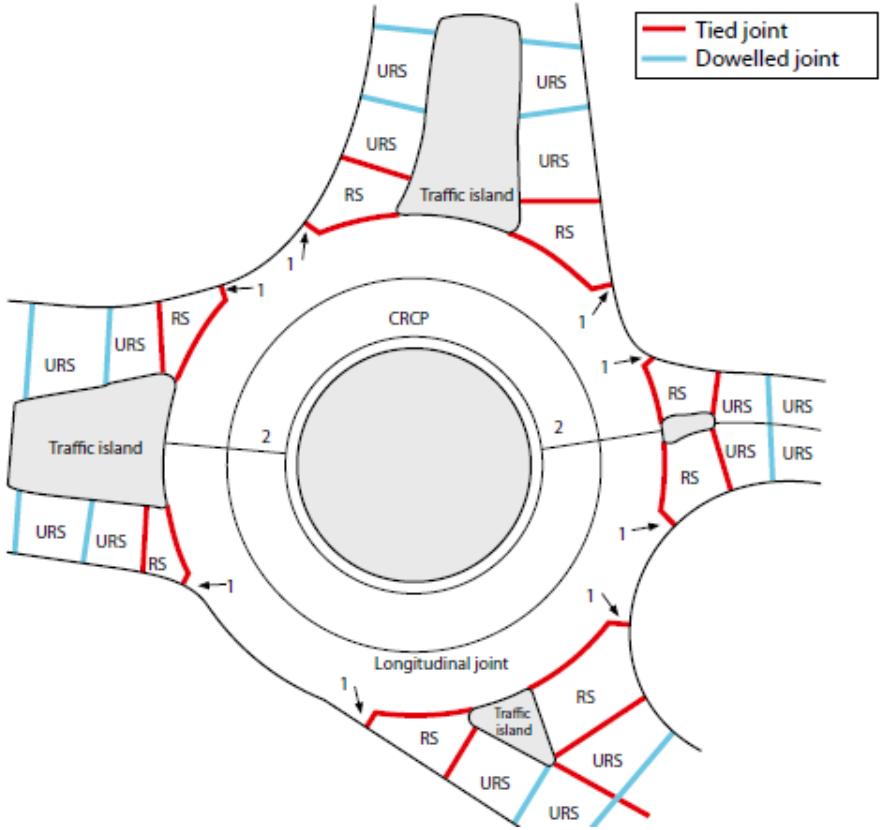


Linear CRCP versus Roundabout CRCP

- Many of the design, construction, and maintenance aspects of CRCP roundabouts are similar to linear CRCP
- Some differences:
  - Linear CRCP has expansion joints at ends, roundabout CRCP would not have any active expansion joints
  - Roundabout CRCP may have one or two non-active transverse construction joints
  - Linear CRCP use tie bars to prevent lane drift, especially for the outside lane. Roundabout CRCP only use tie bars when lane drift may occur.

CRCP Roundabout Use—Europe

- In Europe, low-maintenance CRCP roundabouts have been used at high-volume roadway intersections
- CRCP roundabout use began in the Netherlands in 1995
- Hundreds of CRCP roundabouts have been constructed in Europe
  - » Applications include entrances to industrial areas, freeway exits, and secondary roads



Typical European CRCP Roundabout Design Practices

- Limit longitudinal steel diameter to 0.62 inches
- Longitudinal steel amount: 0.6 to 0.7 percent

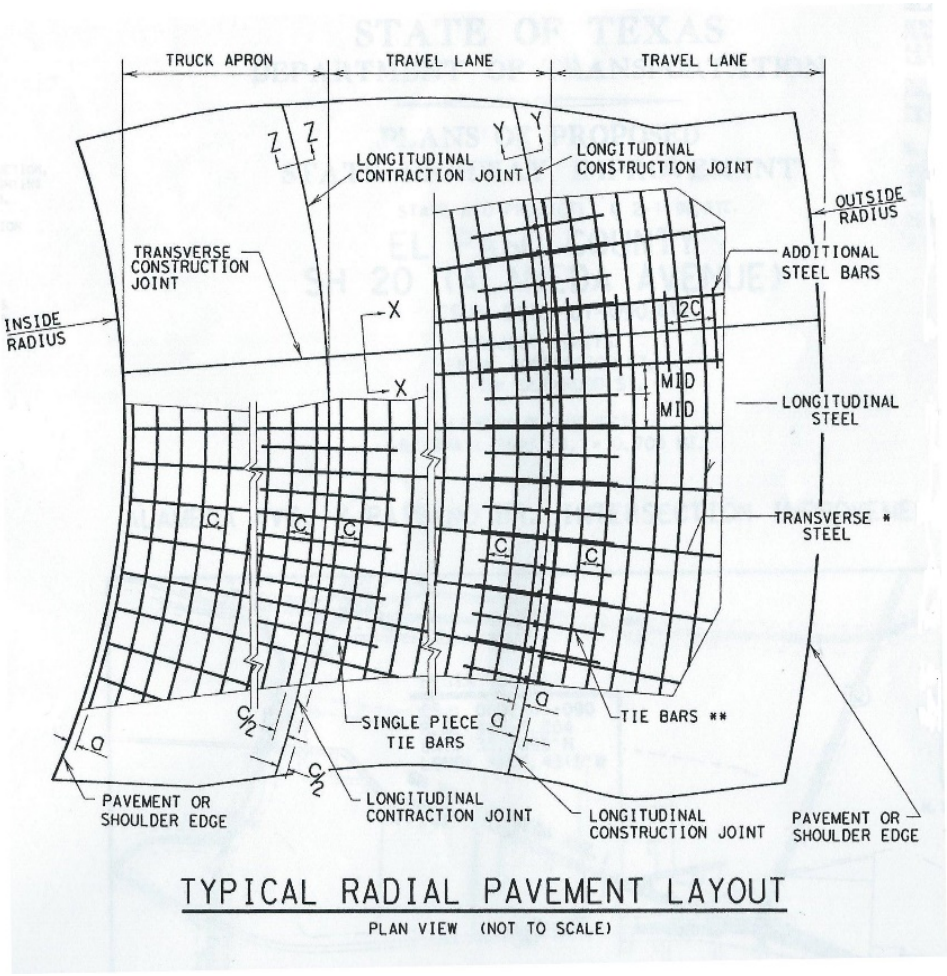
- Length of longitudinal steel bar lap:
  - 35 times the nominal diameter of the steel near the outer perimeter
  - But reduced near the inner perimeter to minimize steel congestion
  - Splices should be staggered
- Nominal diameter of transverse bars: 0.55 inches
- Depth to top of reinforcement: 3.15 inches
- Transverse reinforcement is typically placed radially
- 2-inch thick hot mix asphalt (HMA) base/interlayer typically used to support the reinforcement and to provide the desired level of interface friction

European CRCP Roundabout Construction

- European CRCP roundabouts are typically constructed using forms and a vibrating screed or using slipform pavers for larger roundabouts
- In the Netherlands, a transversely moving roller-finisher is also used for roundabouts
- Concrete may be brought to the center area of the roundabout and distributed to the paver or may be pumped

CRCP Roundabout Use - Texas

- 2013/2014: Two CRCP roundabouts constructed as part of the Alameda Avenue/Paisano Drive intersection improvement project in El Paso County
- 2014: Two CRCP roundabouts were constructed in Walker County
- The roundabouts used TxDOT steel reinforcement details



Texas DOT Longitudinal Steel Requirements for Roundabouts

Slab Thickness, in.	Steel Bar Size	Steel Bar Spacing, in.	First Spacing of Bar at Edge or Joint, in.	Additional Steel Bars at Transverse Construction Joint – Spacing, in.	Steel Bars at Transverse Construction Joint – Length in.
6.0	#5	7.5	3 – 4	15	50.0
6.5	#5	7.0	3 – 4	14	50.0
7.0	#5	6.5	3 – 4	13	50.0
7.5	#5	6.0	3 – 4	12	50.0
8.0	#6	9.0	3 – 4	18	50.0
8.5	#6	8.5	3 – 4	17	50.0
9.0	#6	8.0	3 – 4	16	50.0
9.5	#6	7.5	3 - 4	15	50.0

Texas CRCP Roundabout Use: El Paso County

- Alameda Avenue (SH 20) at intersection with Paisano Drive
- Used to correct 3-way interchange with pedestrian traffic
- Projected 2035 average daily traffic (ADT): 15,400 vehicles per day (vpd), 4.2% trucks
- Designed for a speed limit of 15 mi/hour with pedestrian crossings at the approaches of the roundabouts

Existing Layout ➔

As-Designed Layout ➔

Texas CRCP Roundabout Use: El Paso County (cont'd)

- Two 16-ft wide travel lanes and one 10-ft wide apron lane
- Base/Subbase: 4-inch hot-mix asphalt concrete (HMAC) base/ 6-inch lime stabilized subgrade
- Inside Radius: 46 ft
  - » Apron pavement: 10-inch thick CRCP; No. 6 bar at 7-inch spacing (0.63%)
- Intermediate Radius at Apron: 56 ft
  - » Inside travel lane: 8-inch thick CRCP; No. 6 bar at 9-inch spacing (0.6%)
- Outside Radius: 90 ft
  - » Outside travel lane: 8-inch thick CRCP; No. 6 bar at 9-inch spacing (0.6%)

Texas CRCP Roundabout Use: Walker County

- Two CRCP roundabouts constructed in Walker County in August 2014
  - Along the Farm-to-Market Road 1375 at the Interstate 45 frontage road intersections in New Waverly
  - The new roundabouts replaced existing two-way intersections

© 2014 Google Earth with overlays marking old and new intersections


© 2021 Google Earth

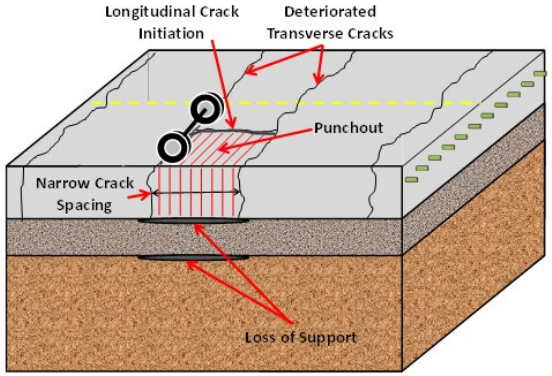
Texas CRCP Roundabout Use: Walker County (cont'd)

- Two 16-ft wide travel lanes and one 10-ft wide apron lane
- Inside Radius: 51-1/2 ft
  - » Apron pavement: 9-inch thick CRCP; No. 6 bar at 6-inch spacing (0.61%)
- Intermediate Radius at Apron: 65-1/2 ft
  - » Inside travel lane: 7-inch thick CRCP; No. 5 bar at 6.5-inch spacing (0.68%)
- Outside Radius: 89-1/2 ft
  - » Outside travel lane: 7-inch thick CRCP; No. 5 bar at 6.5-inch spacing (0.68%)

Texas CRCP Roundabout Use: Walker County (cont'd)

CRCP Roundabout – Pavement Design

- CRCP roundabout should be designed for a service life of 40 years or longer
- The design considerations for CRCP roundabouts are similar to linear CRCP
- Key design details typically include:
  - » Slab thickness
  - » Longitudinal steel content
  - » Base type
  - » Edge treatment for the outer and the apron lanes



© Jeff Roesler

© Shiraz Tayabji

Typical Longitudinal Steel Contents

- Higher steel amounts
  - » Keep transverse cracks tight
  - » Allow for good load transfer over life of CRCP
- Tight cracks also:
  - » Keep out incompressible material and water
  - » Minimizes crack spalling
  - » Greatly reduces potential for development punchouts

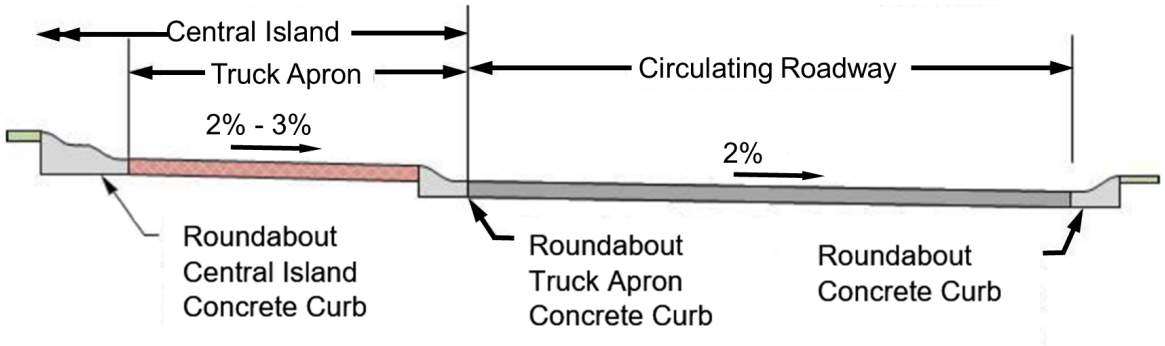
Slab Thickness, in.	Steel Bar Size	Steel Bar Spacing, in.	Percent Steel
9.0	#6	7.0	0.70
10.0	#6	6.0	0.73
11.0	#6	5.5	0.73
12.0	#6	5.0	0.70
12.0	#7	7.0	0.71

Typical Concrete Properties

- Follow agency's typical practices for paving concrete
- Concrete strength (at 28 days):
  - Flexural strength for design purposes – 650 psi
  - Compressive strength for acceptance purposes – 4,000 psi
- Maximum w/cm ratio
  - 0.42 for CRCP exposed to cycles of freezing and thawing
  - 0.45 for CRCP in non-freeze-thaw areas
- Air content (entrained) – As appropriate for the maximum aggregate size used and severity of exposure (climatic region)
- Some agencies limit the COTE of the concrete used in CRCP to less than 6.0×10^{-6}

Truck Apron

- Provides paved area for wheel tracking of long trailers
- May be CRCP, doweled or nondoweled jointed concrete pavement (JCP), or other pavement type
- Separate construction from roundabout circulatory lanes
- Concrete is often colored and/or patterned to differentiate appearance
- Isolation joint typically used between back of curb and truck apron

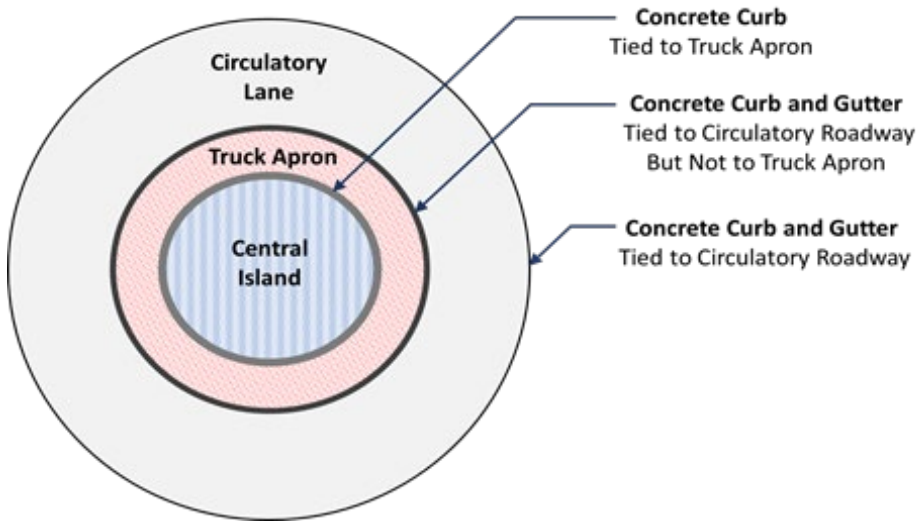


Construction of CRCP Roundabout
(Same as linear CRCP)

- Subgrade preparation
- Subbase and base preparation
  - » Uniform grade for base is very important
- Steel placement
- Concrete placement (fixed form or slipform)
- Concrete surface finishing and curing

Edge Support

- Exterior lane:
  - » Use of a curb placed along the CRCP edge
  - » Use of a curb and gutter adjacent to the lane
  - » Use of an asphalt or a concrete shoulder in rural settings
- Interior lane:
  - » Use of a transition curb between the lane and the apron lane
- Apron lane:
  - » Use of a transition curb between the apron lane and the central island



Deformed tie bars are often used to tie:

- the interior concrete curb and gutter of the truck apron to the circulatory lane.
- the truck apron to the concrete curb of the central island
- the outside curb/gutter to the outside circulatory lane.

Suggested Base Support

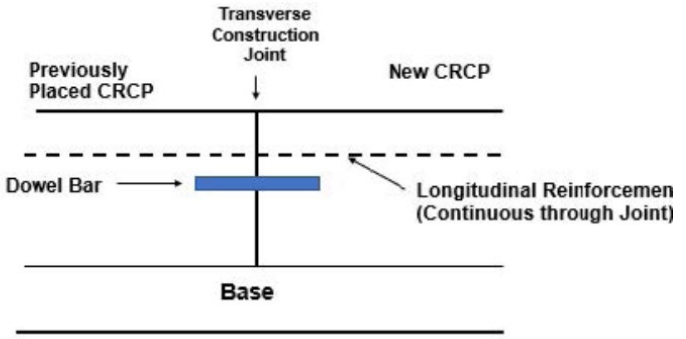
- Granular base for lower levels of truck traffic (< 60 trucks/day)
- HMA base for higher levels of truck traffic
- Cement-treated base (CTB) with an HMA interlayer for higher level of truck traffic.
- Permeable base is not suggested for roundabout CRC

The base surface should result in just enough friction at the concrete slab/base surface interface to promote concrete cracking at spacing of 3 to 6 ft

Transverse Construction Joint Details

- Typical roundabout CRCP lane has at least one transverse construction joint (at start of concrete placement)
  - Additional transverse construction joints are formed at the end of each day of paving, or whenever paving operations are halted long enough to form a cold joint (~30 minutes)
  - Longitudinal steel carried across joint to provide load transfer
  - Deformed dowel bars may be used in wheelpath locations

Federal Highway Administration



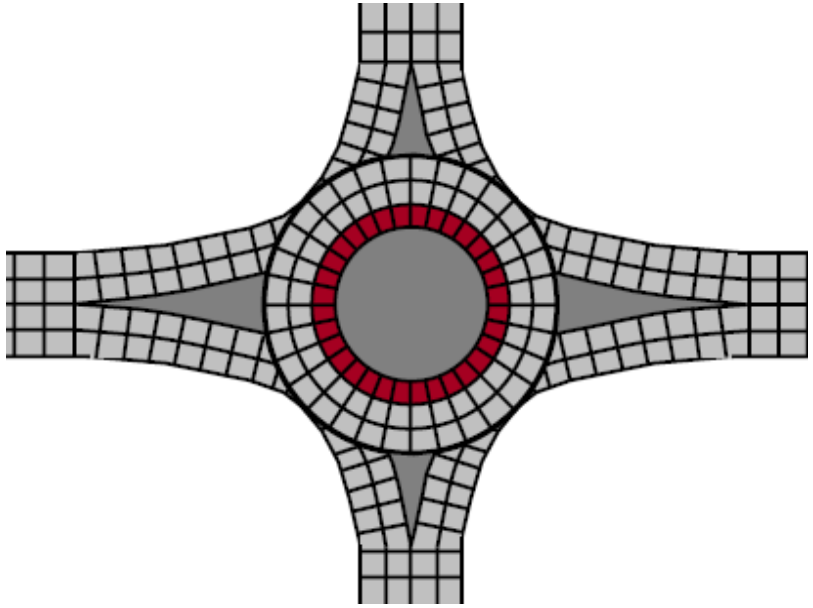
Federal Highway Administration

Isolation Joint and Roadway Transitions

- Typically use same details as in the existing pavement (or modify details as per agency practices)

Summary

- CRCP can offer advantages in roundabout applications
  - Load carrying capacity
  - Long life
  - Low maintenance
- Good long-term performance in Europe
- Several recent projects in Texas
- Design / construction of CRCP roundabouts similar to linear CRCP
- CRCP roundabouts
  - No active transverse expansion joints
  - One or two non-active transverse construction joints
  - May not need tie bars as lane drift is not an issue



Precast Concrete Pavement (PCP) Roundabouts

Transportation Research Board Webinar

Shiraz Tayabji

U.S. Department of Transportation
Federal Highway Administration

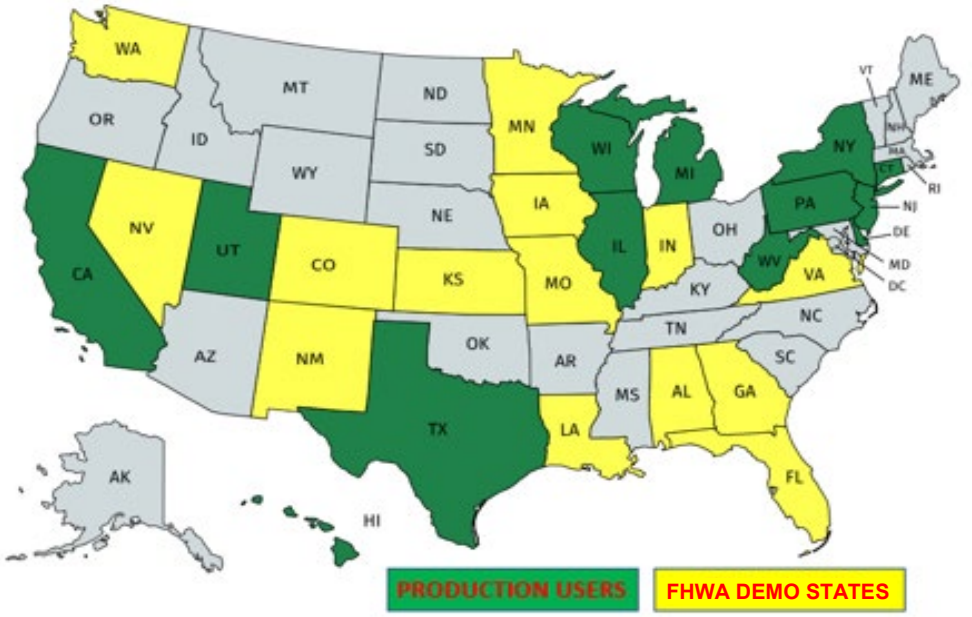
Outline

- Precast Concrete Pavement (PCP) Overview
- PCP Roundabouts
- PCP Technical Considerations
- Design of PCP Roundabouts
- Construction of PCP Roundabouts
- Case Study
- Summary

Except for any statutes or regulations cited, the contents of this presentation do not have the force and effect of law and are not meant to bind the public in any way. This presentation is intended only to provide information to the public regarding existing requirements under the law or agency policies.

Introduction to PCP

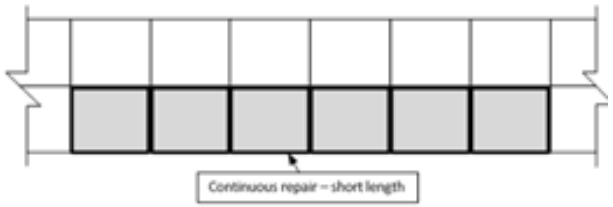
- Production use of PCP started in 2001
- Most U.S. PCP projects constructed since 2005
- Used for rapid rehabilitation of concrete pavements and for reconstruction of heavily trafficked asphalt concrete intersections
- Used for intermittent repairs (full-depth repairs and full slab replacement) and for continuous applications (longer-length rehabilitation)
- Long-life and low-maintenance potential

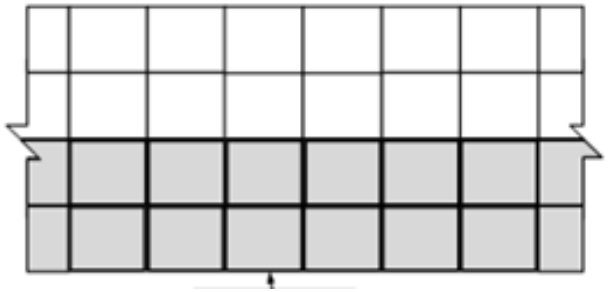


U.S. PCP implementation as of 2020

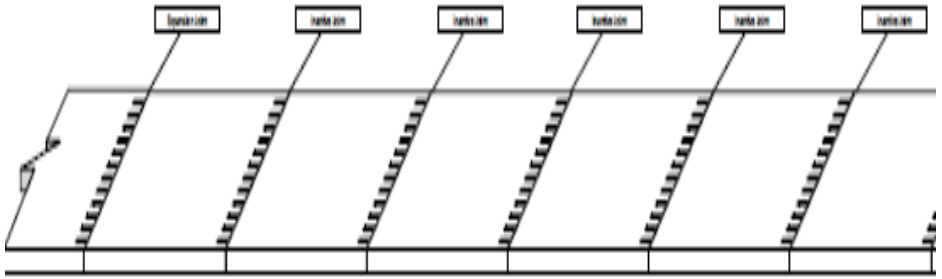
PCP Applications

- Continuous application can be appropriate for rehabilitation of existing jointed concrete pavement (JCP) and hot-mix asphalt pavement (HMAP) roundabouts
- May not be cost effective to construct new roundabouts with PCP
- Very limited experience in the U.S. with PCP use for roundabouts
  - » Virginia DOT PCP roundabout: late 2020
  - » Use of PCP in curved highway sections and ramps





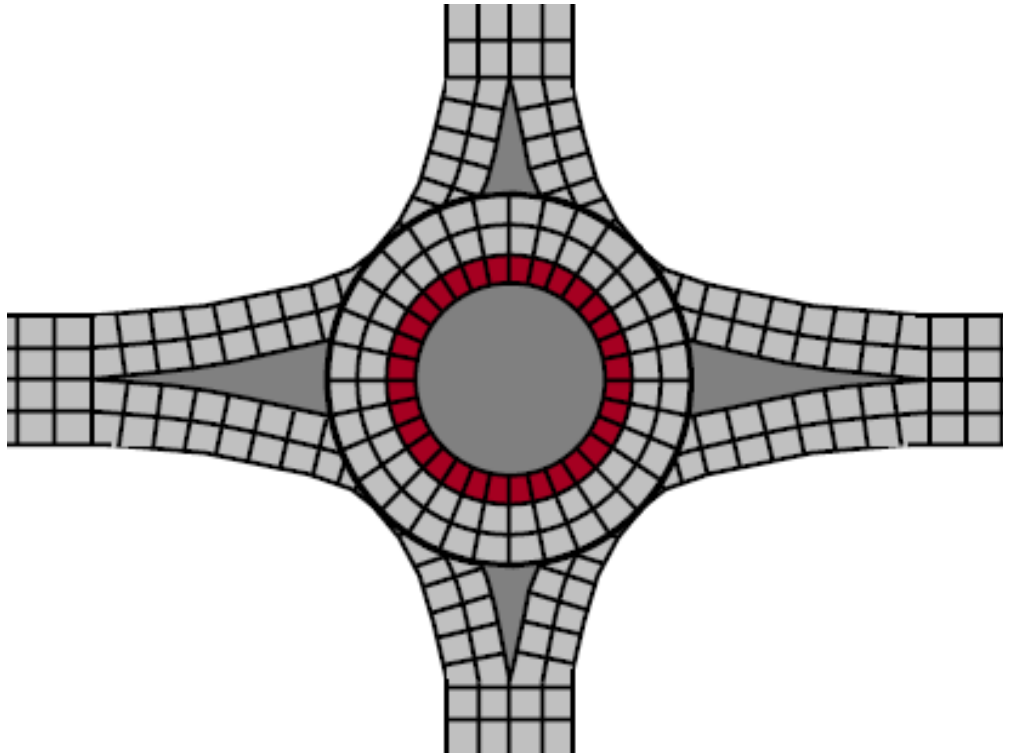
© Shiraz Tayabji



© Shiraz Tayabji

PCP Roundabout Panels

- Use is made of trapezoidal planar panels or non-planar panels
- For this presentation, only the use of trapezoidal planer precast panels is discussed, similar to trapezoidal joint layout for JCP roundabouts
- PCP roundabouts using trapezoidal panels can be expected to perform as well as JCP roundabouts with a trapezoidal joint layout



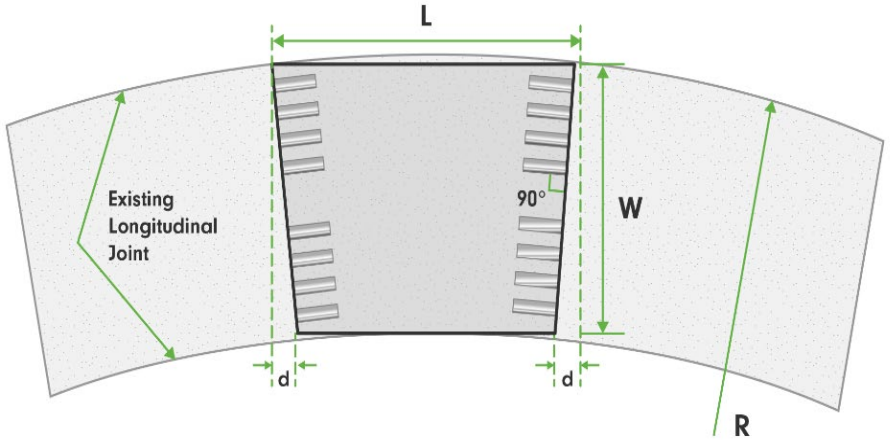
Advantages of PCP Use for Roundabouts

- The precast panel installation technique allows for nighttime rehabilitation (typically one lane at a time) without impacting daytime traffic operations
- Concrete used for the precast panel is placed under controlled conditions at the precast concrete plant and should be more durable
- Higher strength concrete is used for precast panels to allow for form-stripping the next day
- The precast panels are reinforced or pretensioned.
  - Any panel cracking that may develop during service should remain tight and should not impact the roundabout performance

© Shiraz Tayabji

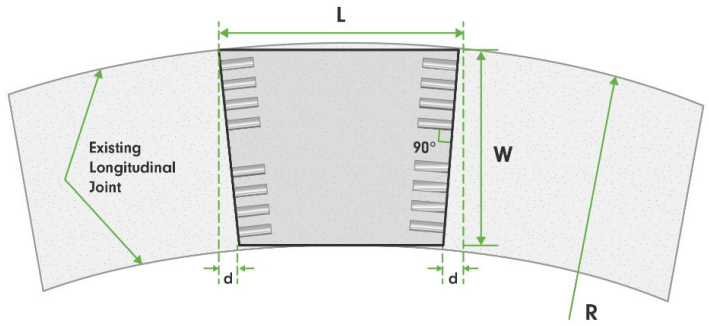
Possible PCP Applications to Roundabouts

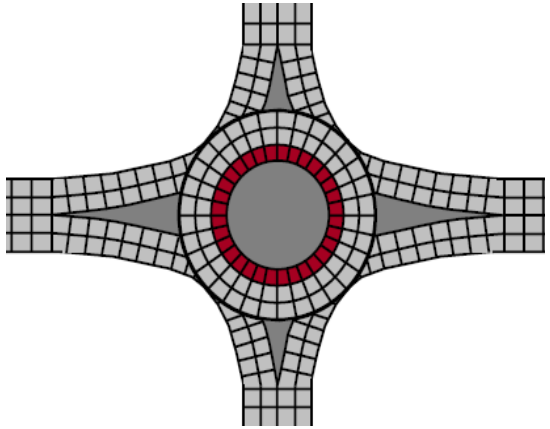
- Rapid reconstruction of an HMAC roundabout
- Rapid rehabilitation or reconstruction of distressed lanes of a JCP roundabout
  - » Single-lane rehabilitation or reconstruction
  - » Multiple-lanes rehabilitation or reconstruction
- The panel installation is typically done along a single lane
  - » About 10 to 15 panels typically can be installed per nighttime lane-closure window
  - » A 100-ft outside diameter roundabout lane (total outside perimeter length of 314 ft), with about 25 to 30 panels, typically can be rehabilitated over 2 to 4 nighttime work windows, depending on lane-closure availability



PCP Technical Considerations

- Concrete characteristics
- Plan details
  - » Panel layout - Consideration of non-planar panel geometry and use of trapezoidal panels
  - » Joint spacing
- Overall panel support conditions
- Panel placement and bedding layer
- Load transfer at transverse joints
- Panel reinforcement
- Panel fabrication
- Panel installation



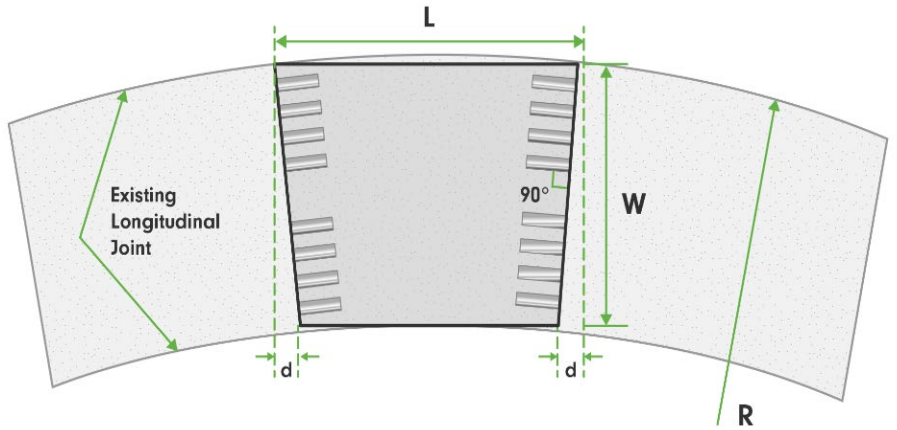


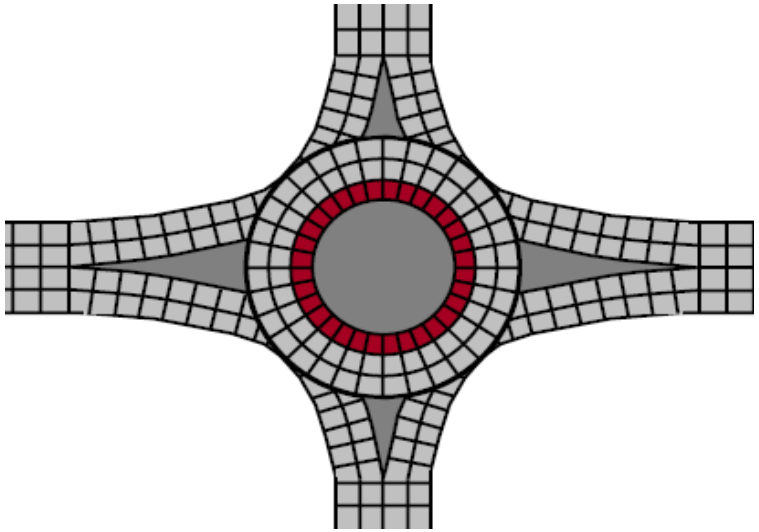
Typical Concrete Characteristics
(Similar to paving concrete)

- Concrete compressive strength (at 28 days)
  - 4,000 to 6,000 psi
- Form stripping compressive strength (~16 hrs)
  - 2,500 psi
- Maximum w/c-m ratio
  - 0.42 to 0.45 for pavements exposed to freeze-thaw
  - 0.45 to 0.50 for other pavements
- Air content—As appropriate for the maximum aggregate size used and severity of exposure
- Durability
- Surface texture as per agency standards

Panel Details: Consideration of Non-Planar Panel Geometry

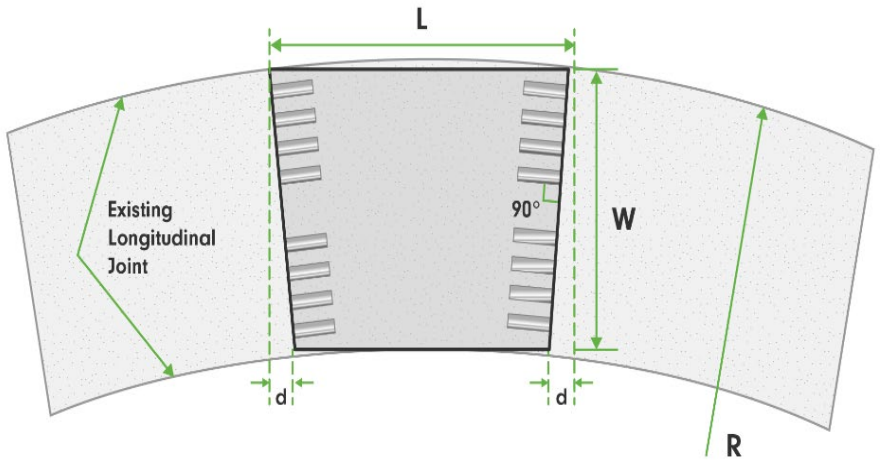
- The panels are nominally trapezoidal in shape
- A radial transverse joint pattern across the travelling lanes and the apron lane should be used or preserved from an existing JCP roundabout that is being rehabilitated





Example Trapezoidal Panel Details

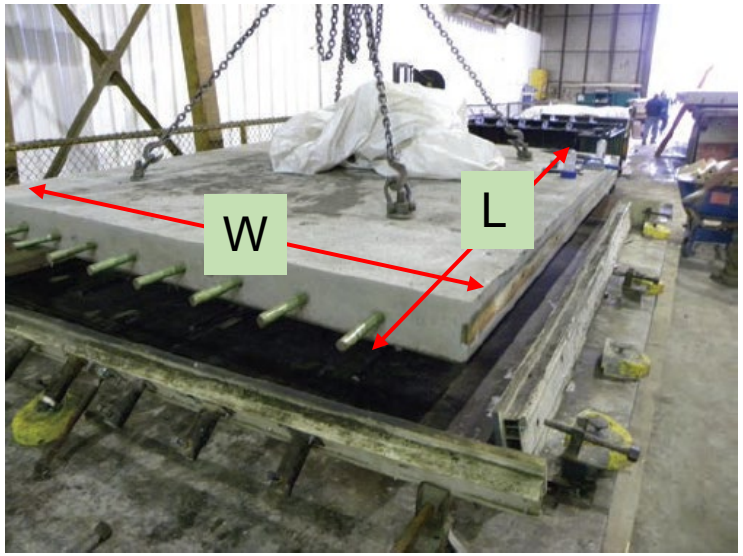
Outside Lane Circumferential Radius, R, ft	Lane Width, W, ft	Panel Outside Circumferential Length, L, ft	Shortening of the Panel Inside Circumferential Length at Each Corner, d, inches (Rounded)
60	12	10	12-1/8
80	12	10	9-1/8
100	12	10	7-1/4
60	12	12	14-1/2
80	12	12	10-7/8
100	12	12	8-3/4



Outer Lane Radius, R, ft	Outer Perimeter Length, ft	Approximate No. of 12 ft wide & 10-ft long panels
60	377.1	34
80	502.9	46
100	628.6	57

Typical Joint Spacing/Panel Length

- PCP panels used for continuous applications are single-lane wide, with panel widths (W) of about 12 to 13 ft to match most typical pavement lane widths
- One panel dimension is typically less than 12 ft because of over-width permitting requirements during transport



- If the panel width is more than 12 ft, then the panel length, L, including exposed dowel bars, is typically limited to 12 ft (to accommodate transport)

Overall Panel Support/Base

- PCP use for roundabouts will most commonly be for rehabilitation of existing HMAP or JCP roundabout traffic lanes
- The existing base can be used if not damaged during the surface layer removal
- The existing base may be reworked, trimmed, graded, and compacted, and a thin bedding material can then be used to level the base grade

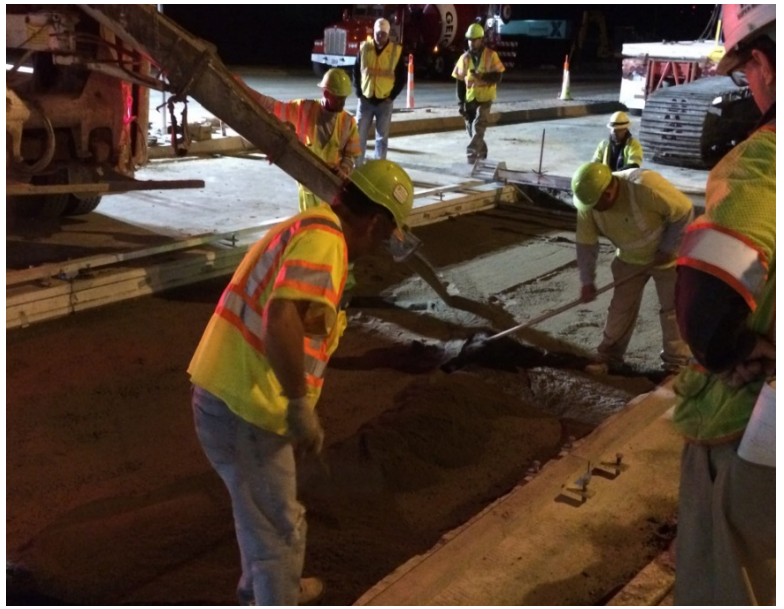
Overall Panel Support/Base (cont'd)

- Alternatively, a new base can be installed
  - » Dense-graded, free-draining granular base for lower truck traffic (<60 trucks/day)
  - » Rapid-setting lean concrete base (RSLCB) for higher levels of truck traffic
    - Many PCP applications (e.g., CA) have used RSLCB material produced at project site using mobile mixers
    - Typical RSLCB characteristics:
      - 500 psi minimum within 1 hour of placement to allow installation of panels
      - 750 psi minimum to 1200 psi maximum at 7 days

© Shiraz Tayabji

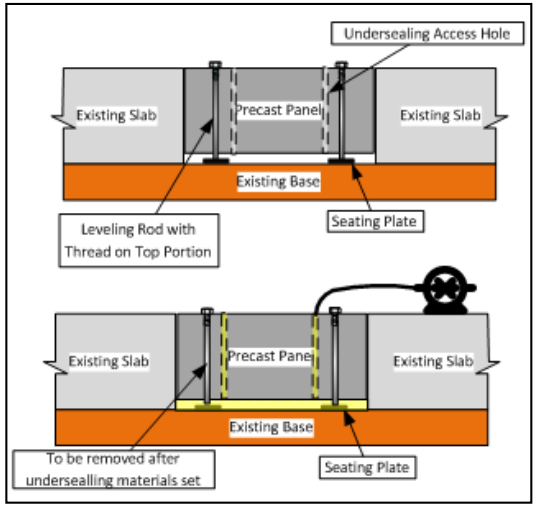
Bedding Layer for Grade-Placed Panels

- A bedding layer is typically used to provide uniform contact between the smooth bottom of a panel and
  the graded/finished base
- Panels are placed over a thin bedding layer of cemented granular material or cemented sand (typically about ¼ to ½ inch thick)
- Surface grinding of the panels typically performed at transverse joints



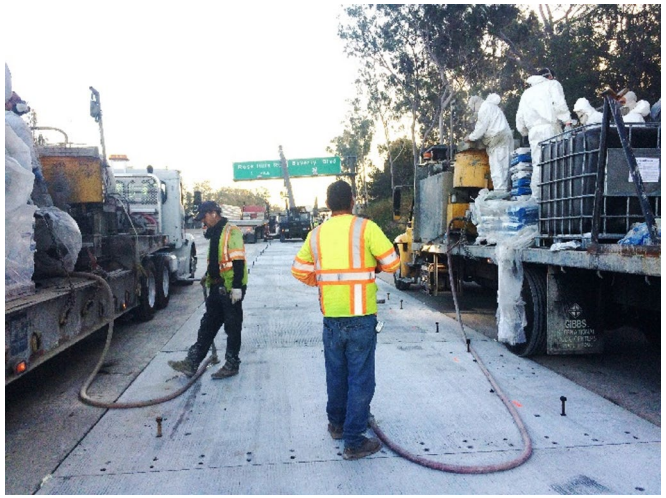
Bedding Layer for Grout Supported Panels

- Panels typically are set about ¼ to ½ inch above the completed base using leveling lifts
- Fast-setting flowable cementitious grout used to fill any gaps
  - » Typical compressive strengths:
    - 500 psi at the time of opening to traffic
    - 3,000 psi at 28 days



© Shiraz Tayabji

© Shiraz Tayabji

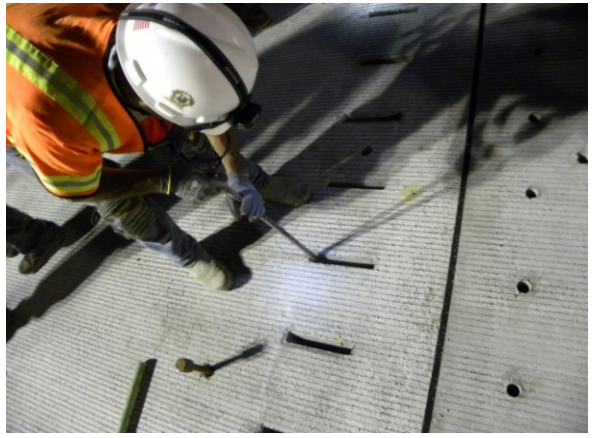


© Shiraz Tayabji

Load Transfer at Transverse Joints

- Load transfer is provided by dowel bars installed in slots or ducts fabricated along one transverse side of a panel
  - One system uses dowel slots formed in the bottom surface of the panel
  - Other systems use dowel slots formed in the top surface of the panel
  - A bulgy full-depth slot may be used at the beginning and end of a section






Dowel Bar Slot Grout & Patching Material

- Dowel bar slots are typically grouted or patched right after the panel installation (i.e., during a single lane closure)
- Typical pavement owner agency strength requirements:
  - 2,500 psi within 1 hour or by the time of opening the PCP section to early morning traffic
  - No Federal requirement
- The dowel bar slot grout or patching materials are typically rapid-setting proprietary materials and may be free-flowing cementitious or polymer-based, with or without aggregate

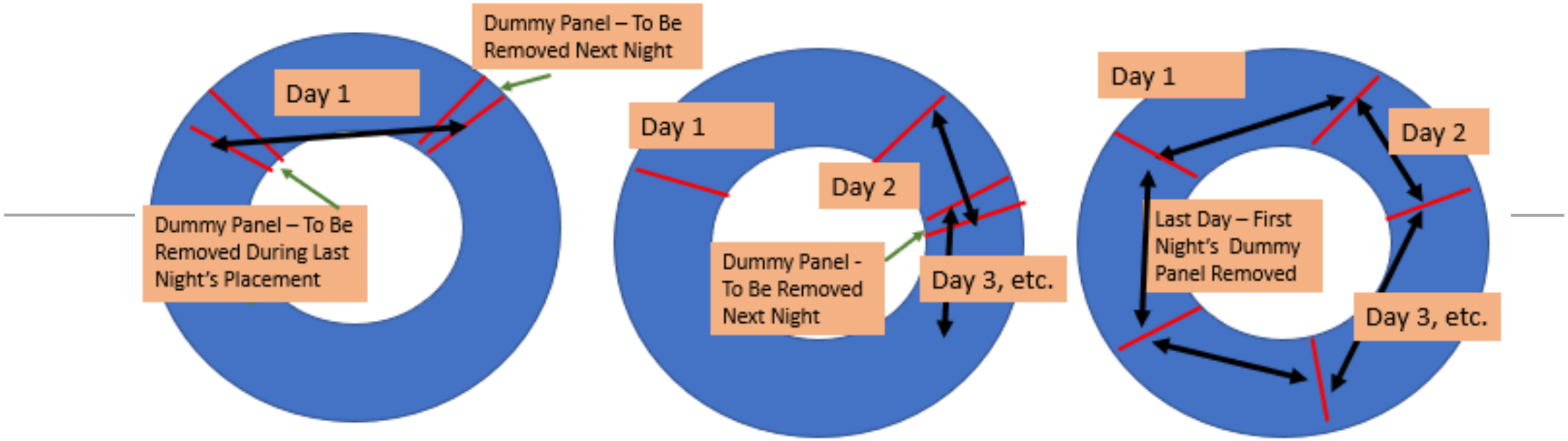
Panel Fabrication Process

- Panels are fabricated in accordance with the approved fabricator shop drawings
- Fabrication involves:
  - Setting up the formwork
  - Installing hardware (reinforcement, lifting inserts, etc.)
  - Provisions for blockouts and grout ports
  - Placing and finishing concrete, including surface texture
  - Applying curing compound onto the panel surface
  - Stripping forms & removing dowel and tie-bar slot blockouts
  - Applying curing compound to panel sides
  - Storing panels at the plant, typically for at least 14 days

Panel Fabrication – Shop Drawings

- The shop drawings also include details on how the panels fit together and provide information for panel installation around a complete roundabout lane:
  - Design of the first panel, the intermediate panels and the last panel, including dowel bar design/layout
  - Design of trapezoidal dummy panels to be used between successive night's panel placement

Construction of PCP Roundabouts

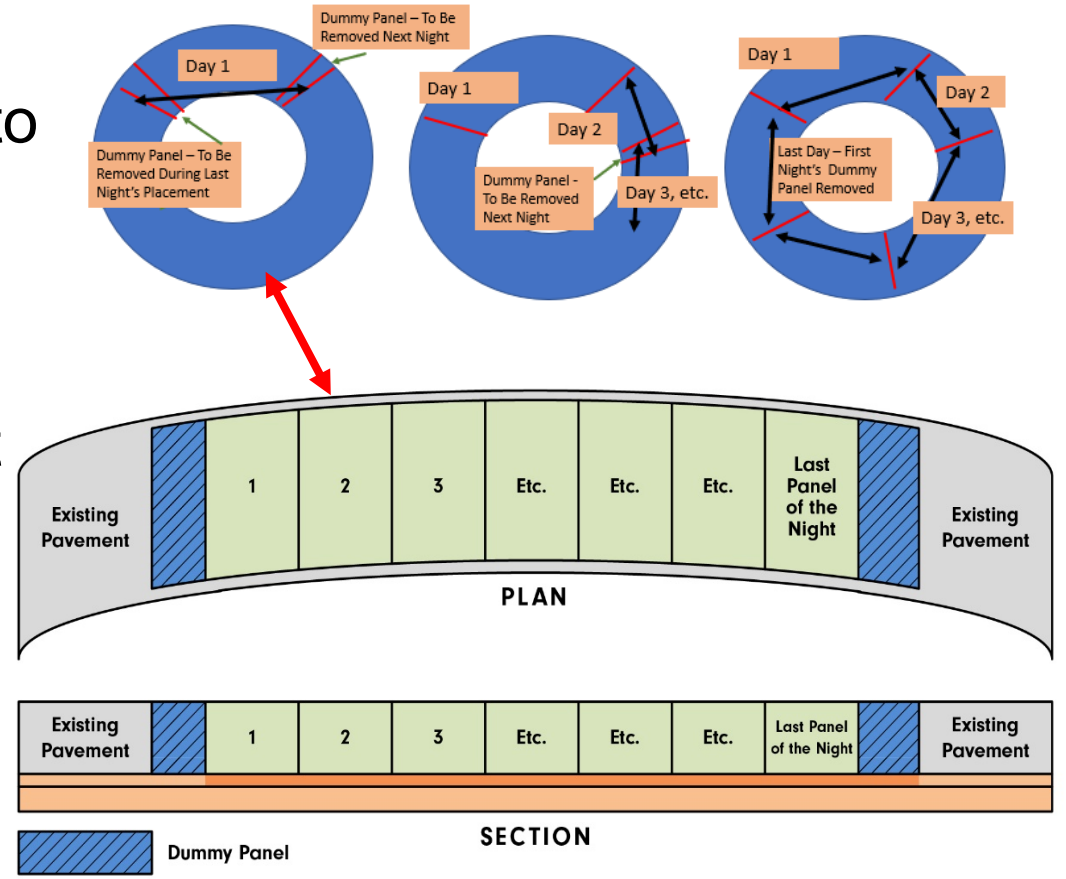


Traffic Staging

- PCP work typically performed in stages during short nighttime work windows
- Work can be performed along one lane and one additional lane, or the apron or the outside shoulder can be used for construction traffic
- The length of the lane that can be worked upon typically ranges from about 150 to 200 ft (outside perimeter length), involving placement of about 15 to 20 panels
- The panel length (outside perimeter length) may range from 10 to 12 ft
- The staging of the panel placement operation can allow for partial use of the roundabout during the nighttime
  - Typical construction window: 7 pm to 6 am

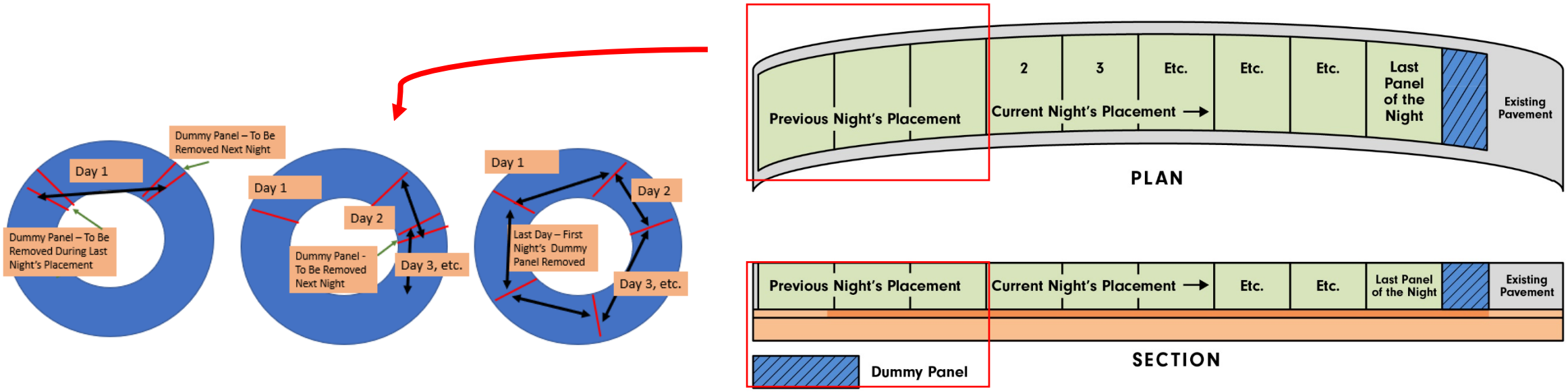
Construction Process – Panel Placement

- For the roundabout continuous application, the area to be worked depends on the number of panels to be installed during that lane closure
- The longitudinal width of the work area is equal to the panel width plus 1 to 1.5 inches to accommodate the roundabout curvature during panel placement
- The length of the work area should accommodat the total length of the panels to be placed that night, plus ¼ to ½ inch for each transverse joint gap
- In addition, the work area length should account for the length of the dummy panel to be placed after the last panel



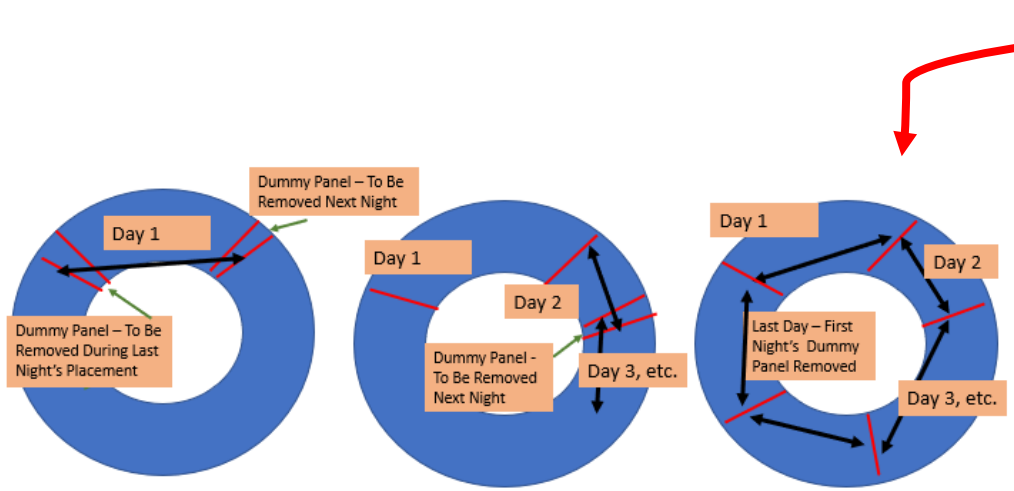
Construction Process – Panel Placement (cont'd)

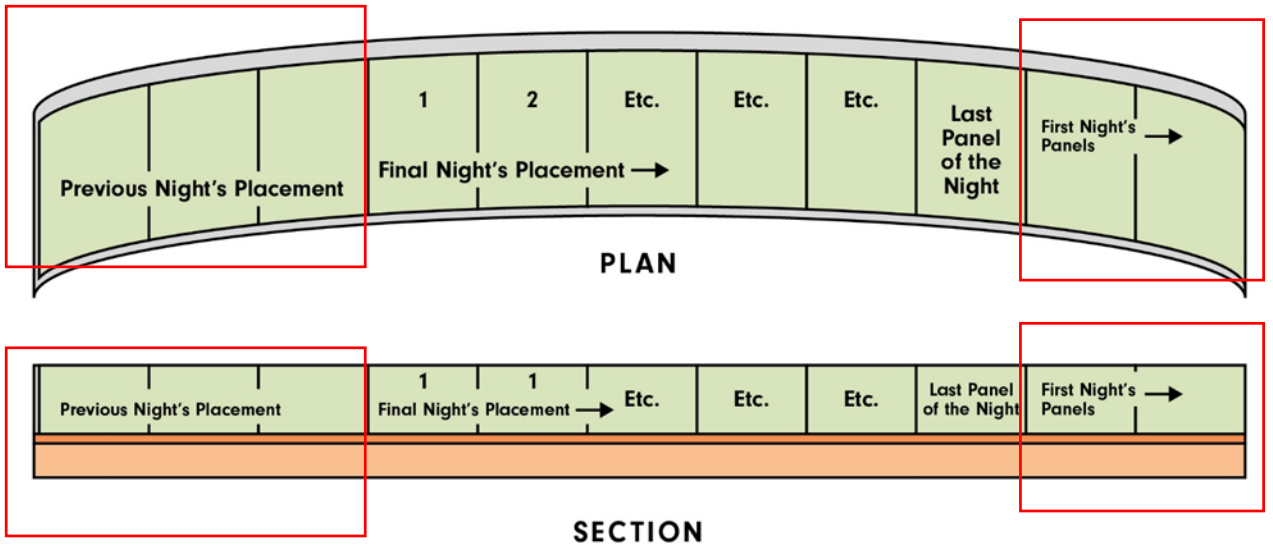
- For each successive night of panel placement, the dummy panel placed at the end of the previous night's panel placement is removed and the panel placement process is repeated



Construction Process – Panel Placement (cont'd)

- For the last night of panel placement, the dummy panel placed at the start (night 1) of panel placement is removed and last panel is placed at that location



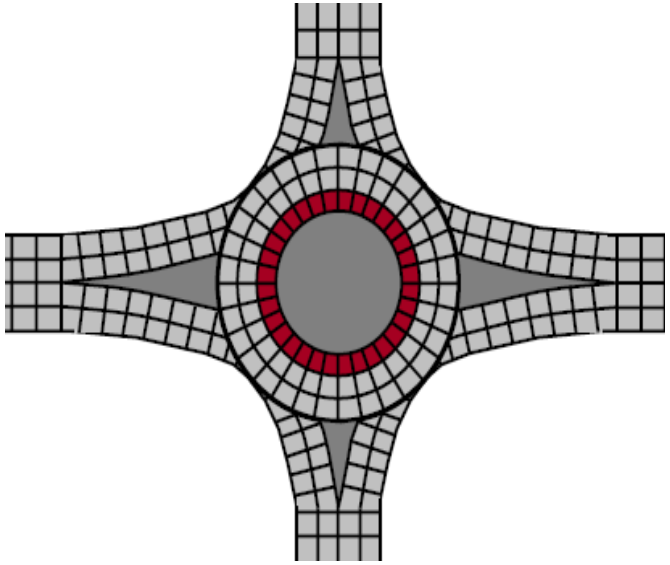


Edge Support

- When an existing roundabout is being rehabilitated, the following edge support features may be used in the structural design of the PCP roundabout pavement:
  - Exterior lane:
    - Use of a sleeper slab at intersections with approach/exit lanes
    - Use of a curb placed along the PCP edge
    - Use of a curb and gutter adjacent to the lane
    - Use of an asphalt or a concrete shoulder
  - Interior lane: Use of a transition curb between the lane and apron
  - Apron lane: Use of a transition curb between the apron and central island

Longitudinal Joint Details

- For PCP roundabouts, tie bars typically are used only where lane drift may occur
- With lane-at-a-time construction, the longitudinal joint is a simple butt-joint
- The longitudinal joint gap is filled with an asphaltic filler material or the dowel slot grout material
- The joint should be sealed in accordance with the agency practice



Summary

- PCP can offer many advantages, including:
  - Concrete panel fabrication under controlled conditions
  - Adverse paving conditions typically do not affect concrete quality or durability
  - Higher strength of concrete can allow for longer service life
- Very limited U.S. experience with PCP roundabouts, but good strategy for rapid (overnight) rehabilitation of existing distressed JCP or HMAP roundabouts
  - Carry heavy truck traffic and buses
  - Minimal maintenance
  - Minimal disruption to traffic during construction and once constructed

Precast Concrete Pavement (PCP) Roundabouts – A Virginia Case Study

Transportation Research Board Webinar

Shabbir Hossain

U.S. Department of Transportation
Federal Highway Administration

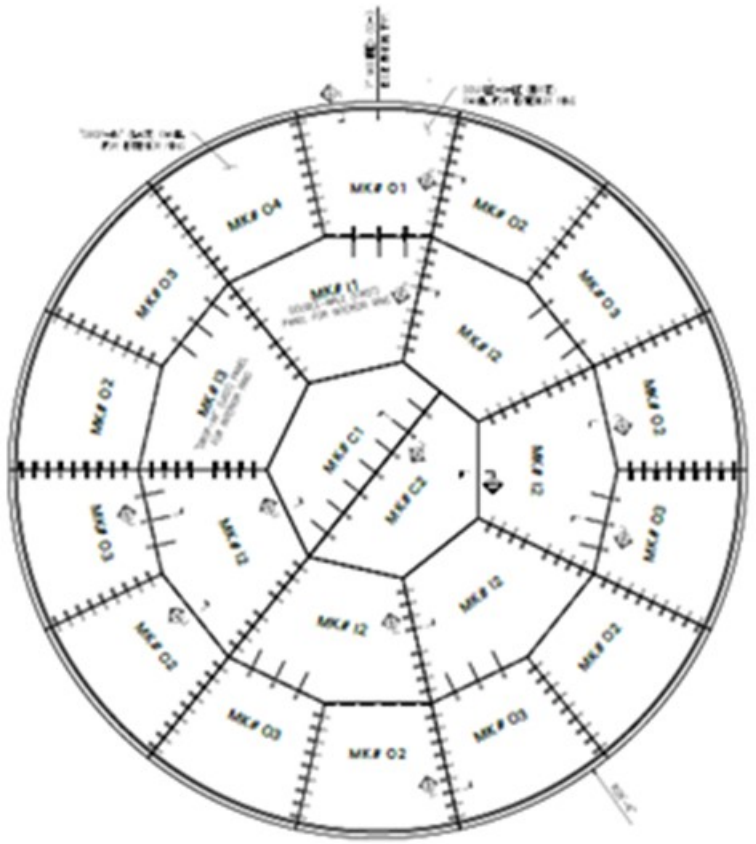
Virginia DOT PCP Roundabout

- Constructed in December 2020 (over a weekend)
  - » Easier maintenance of traffic (MOT)
- Intersection application
  - » Route 197 (Laburnum Ave.), Richmond, VA
  - » Converting four-way intersection to a roundabout
- Truck apron (central island) only (57 ft diameter)
  - » Circulatory lanes constructed of HMA
  - » Pre-cast panels raised 3-in

Virginia DOT PCP Roundabout

- Precast panels
  - Trapezoidal panels for outer ring; polygonal panels for inner ring and median area
  - 9 inches thick and nominally 10 ft wide for the outer and inner rings; grout supported panels (using leveling lifts)
  - 23 panels jointed together by dowels and ties bars

VDOT PCP Roundabout Project: Preliminary Work and Mock-Up Installation



Shop Drawing of Panel Layout

Mock-Up Installation in NY State Precast Plant (2 weeks prior)

Video Casted for Construction Crew Training

VDOT PCP Roundabout Installation

Panels stacked on site

Milling old asphalt (Friday night)

Spreading sand cement leveling layer

VDOT PCP Roundabout Installation

Installation of median panel

Installation of panels continued along with final grade preparation

VDOT PCP Roundabout Installation

Spraying debonding oil

Panels for truck apron in place

VDOT PCP Roundabout Installation

Adjusting panel elevations using leveling lifts

Bedding grout installation (fill ¼ to ½ inch gap under panel)

Joint sealing

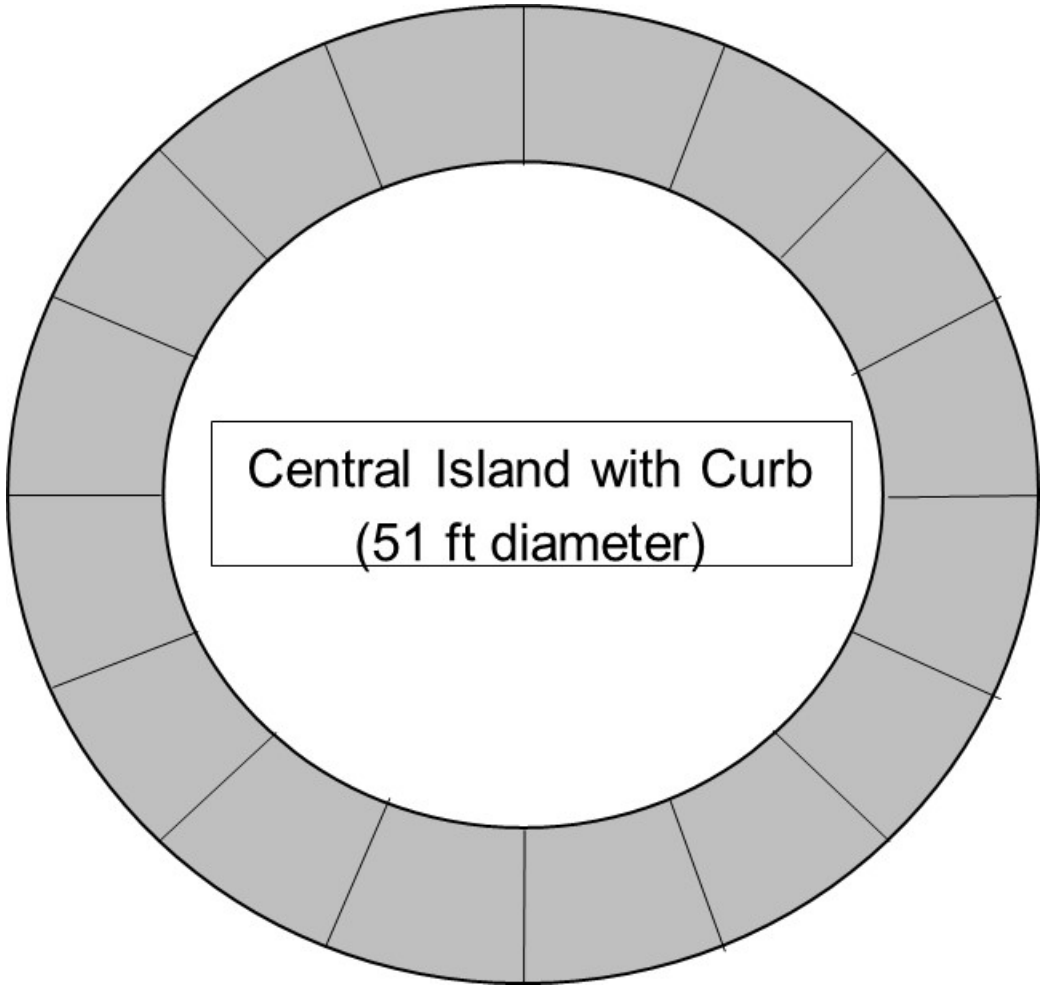
VDOT PCP Roundabout Installation

Installation completed Monday morning

Performing well after one year traffic

VDOT 2nd PCP Roundabout Construction

- Existing four-way intersection
  - » Chesterfield, VA
  - » Route 637 (Hopkins Rd) and
  - » Route 611 (Kingsland Rd)
- Converting to roundabout
  - » Central Island – 51 ft diameter
  - » Precast - Truck Apron only (3-in raised)
  - » 16 ft circular lane HMA
- Precast panel fabrication on-going
  - » 16 Trapezoidal panels
  - » 11 ft wide and 9 inch thick
- Expected construction early 2022



Precast Truck Apron – 11 ft wide

Thank You!

Today's Panelists

Moderator:
Kurt Smith

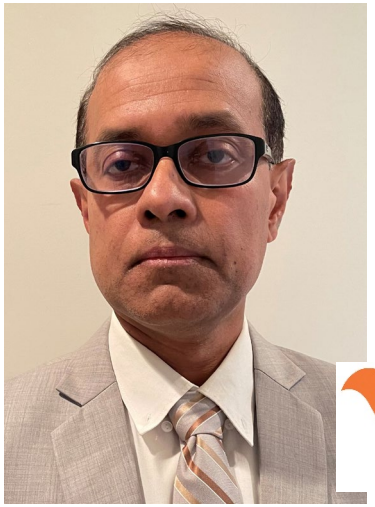
applied pavement TECHNOLOGY

Shiraz Tayabji,
Advanced Concrete Pavement Consultancy, LLC

Jeffrey Shaw

U.S. Department of Transportation
Federal Highway Administration

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE



Shabbir Hossain

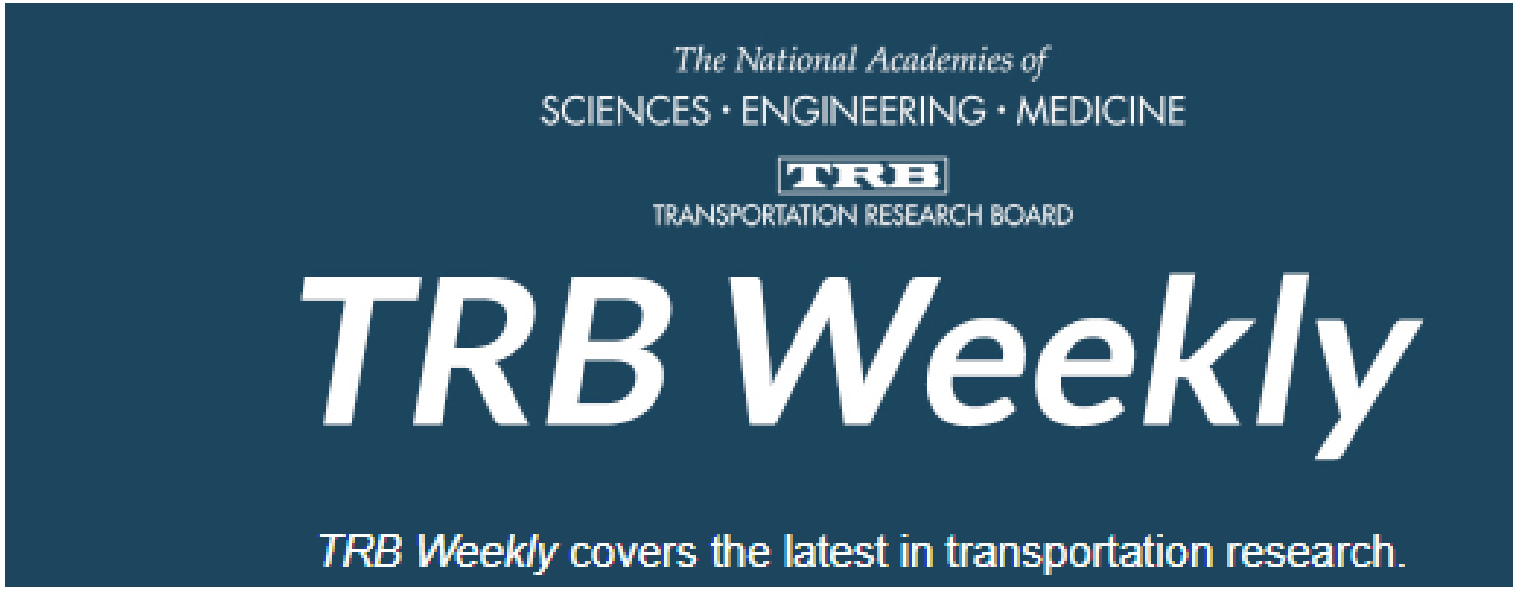
VDOT
Virginia Department of Transportation

#TRBwebinar

Register for TRB's Annual Meeting!

Register now for our January meeting! ***There will be no onsite registration this year.***

#TRBAM



- Subscribe to the newsletter for the most recent TRB news & research!

https://bit.ly/ResubscribeTRBWeekly

TRB's New Podcast!

- Have you heard that we have a new podcast, TRB's Transportation Explorers?
- Listen on our website or subscribe wherever you listen to podcasts!

#TRBExplorers

Get involved with TRB

- Receive emails about upcoming webinars:

https://mailchi.mp/nas.edu/trbwebinars

- Find upcoming conferences:
  http://www.trb.org/Calendar

#TRBWebinars

Get Involved with TRB

#TRBwebinar

@NASEMTRB

@NASEMTRB

Transportation Research Board

Getting involved is free!

Be a Friend of a Committee bit.ly/TRBcommittees

- Networking opportunities
- May provide a path to Standing Committee membership

Join a Standing Committee bit.ly/TRBstandingcommittee

Work with CRP https://bit.ly/TRB-crp

Update your information www.mytrb.org