

TRANSPORTATION RESEARCH BOARD

TRB Webinar: Hit the Ground Running— Designing Roundabouts with Conventional Pavement

November 17, 2021

2:00- 3:30 PM Eastern

@NASEMTRB
#TRBwebinar

PDH Certification Information:

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

#TRBwebinar

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.



REGISTERED CONTINUING EDUCATION PROGRAM

Learning Objectives

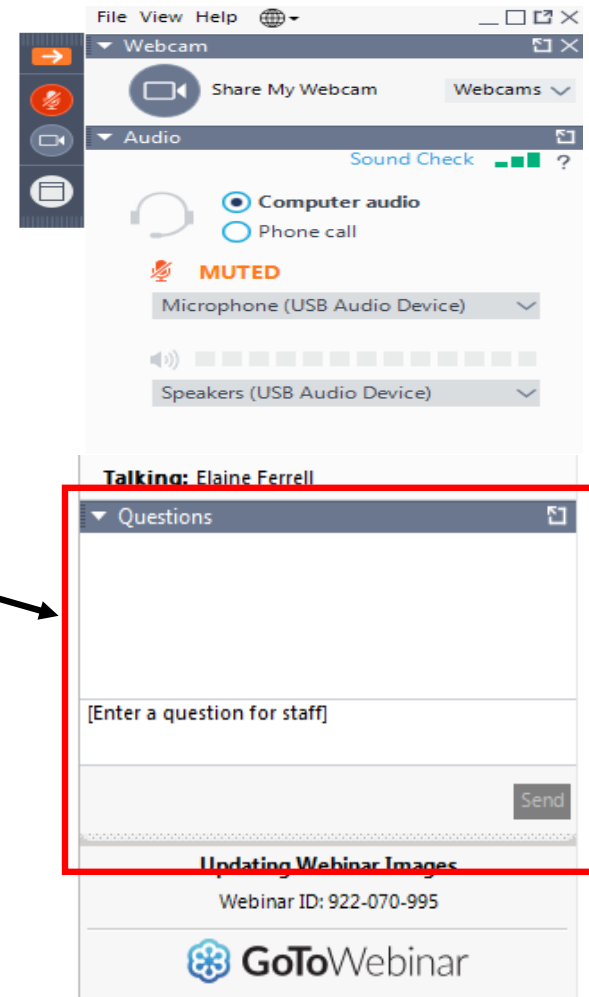
- Identify typical applications for HMAP and JCP
- Discuss key construction and performance considerations
- Discuss safety improvements that roundabouts provide

#TRBwebinar



Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



#TRBwebinar



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FHWA Tech Briefs on Pavement Roundabouts

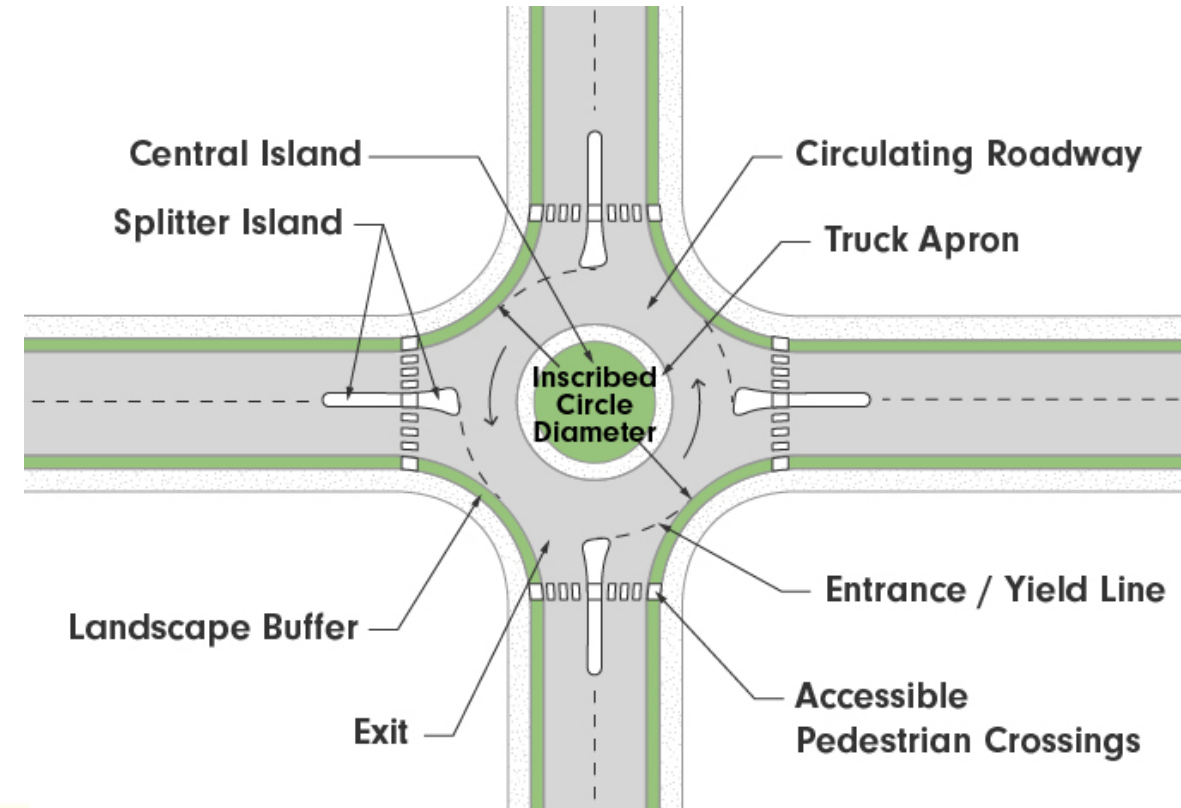
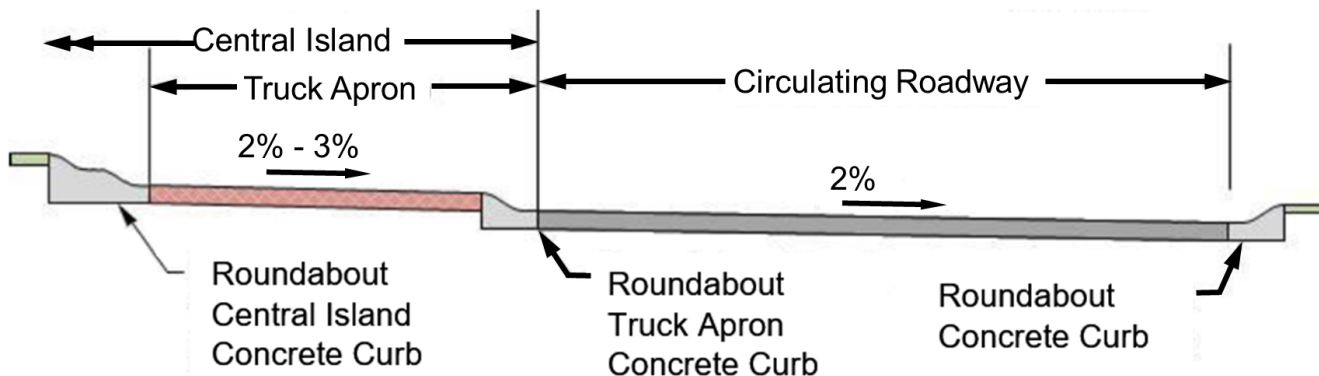
- Tech Brief: Hot-Mixed Asphalt Pavement (HMAP) Roundabouts
- Tech Brief: Jointed Concrete Pavement (JCP) Roundabouts
- Tech Brief: Continuously Reinforced Concrete (CRC) Roundabouts
- Tech Brief: Precast Concrete Pavement (PCP) Roundabouts

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

Brief Introduction to Roundabouts

Introduction to Roundabouts

- Circular intersection
 - » Traffic travels counterclockwise around a central island
 - » Entering traffic yields to circulating traffic



Federal Highway Administration

Potential Benefits of Modern Roundabouts

- Better overall safety performance
- Shorter delays and shorter queues
- Better management of speed
- Lower management and operation costs
- Aesthetic value



Federal Highway Administration

Example Roundabouts



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HOT MIX ASPHALT PAVEMENT (HMAP) ROUNDABOUTS



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**Transportation Research Board Webinar
Month, Day, Year**

Steve Seeds

Outline

- Introduction to Roundabouts
- HMAP Roundabouts
- Pavement Design Considerations
- Pavement Construction
- Summary

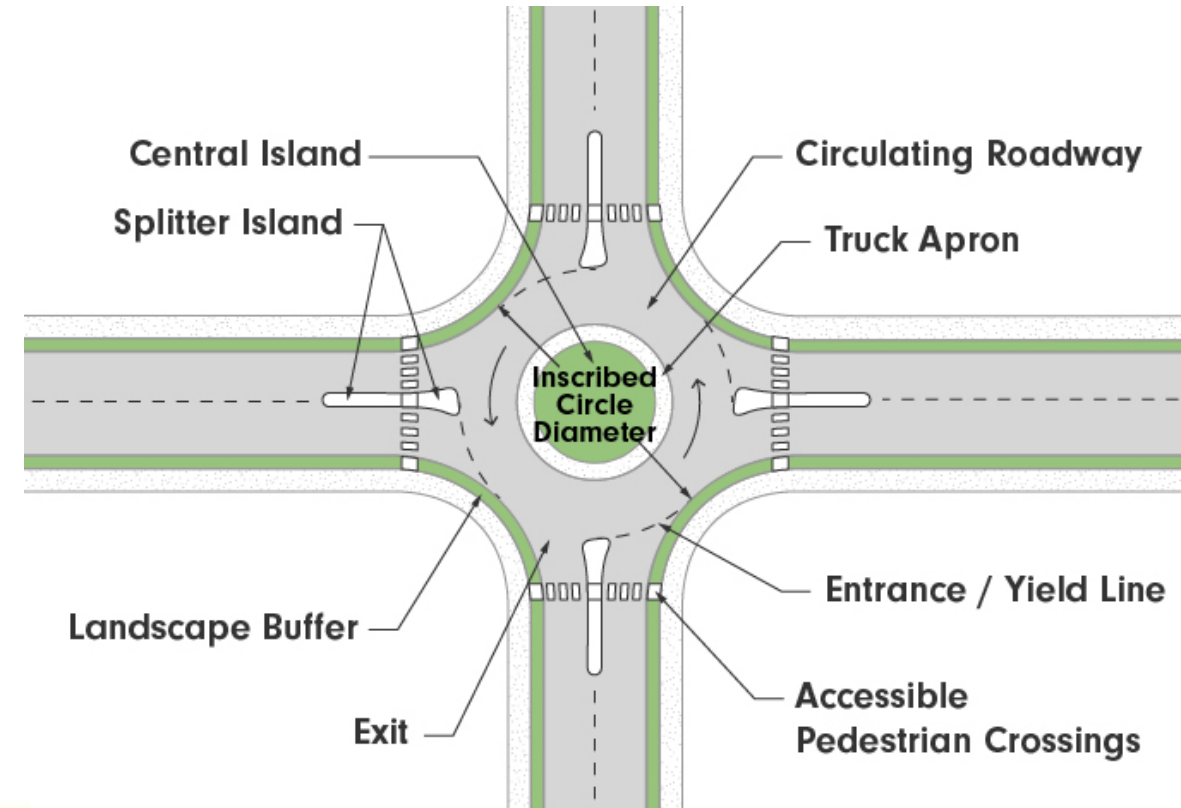
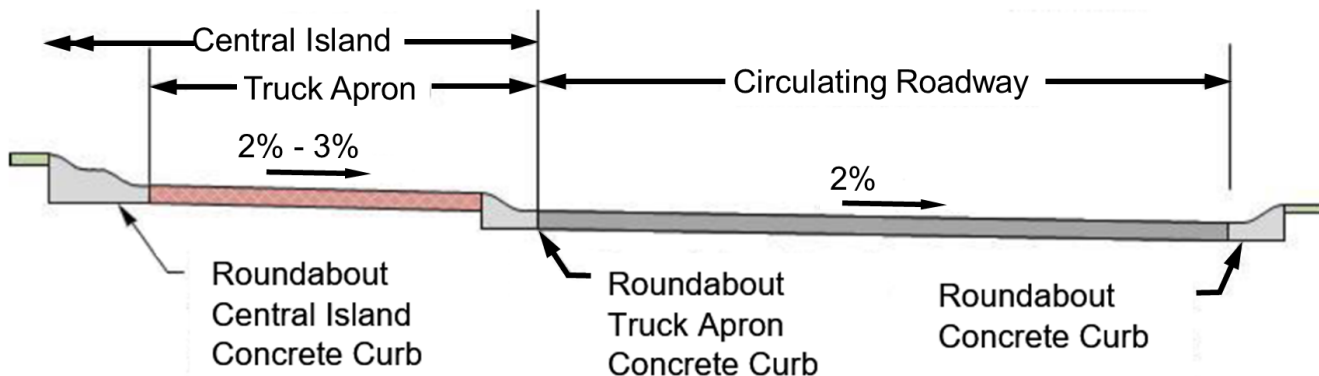


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Introduction to Roundabouts

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Federal Highway Administration

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Federal Highway Administration

HMAP Roundabouts

HMAP Roundabouts

- Hot-mix asphalt (HMA)
 - » Most common paving material used in roundabouts
 - » Can be quickly and easily constructed



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Federal Highway Administration

HMAP Roundabouts



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HMAP Roundabouts



Before

© 2020 Montana Department of Transportation

I-90, Missoula, MT
(Van Buren Street Interchange)



After

© 2020 Montana Department of Transportation

HMAP Applications and Effectiveness

- Typical HMA applications
 - » All roundabout types
 - » Wide range of traffic conditions
- Possible HMAP benefits
 - » Low initial cost
 - » Availability of qualified contractors
 - » Ease of construction/rehabilitation
 - » Satisfactory long-term performance
 - » Access to subsurface utilities
 - » Contrast against pavement markings and truck aprons



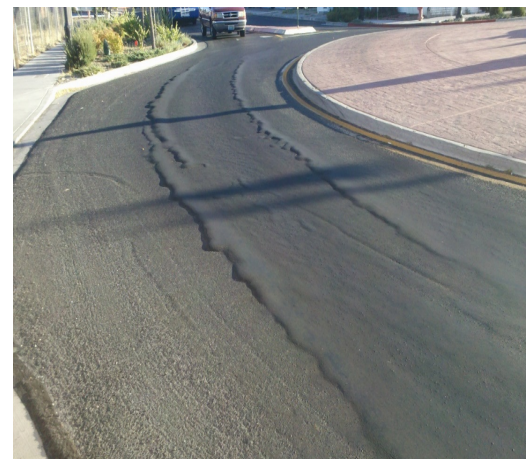
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HMAP Applications and Effectiveness (cont'd)

- Potential performance issues
 - » Traffic negotiating circular pattern
 - Shoving of the asphalt
 - » Traffic braking forces
 - Potential cracking/tearing of surface layer
 - » Slow-moving heavy traffic
 - Rutting



Federal Highway Administration



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Pavement Design Considerations

Pavement Design Considerations

- Asphalt materials and mixture design
- Structural thickness design
- Truck apron



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Asphalt Materials and Mix Design

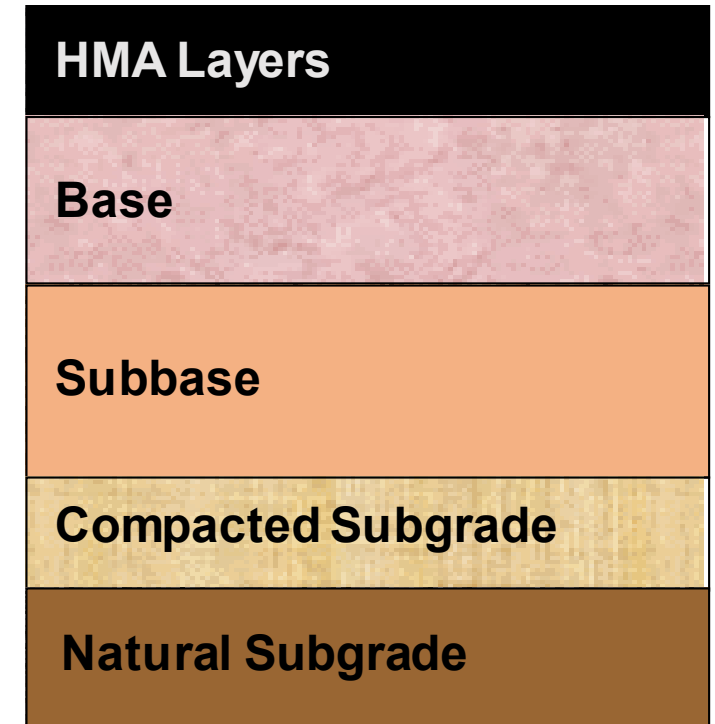
- Asphalt materials and mixture design procedures similar to those used for conventional HMA roadways
- Follow agency mixture design practices for intersections and heavy-duty pavements
- Identify key loading conditions that may impact mixture design
 - » Heavy, slow-moving channelized traffic
 - » Areas subject to severe braking or lateral shear

Asphalt Materials and Mix Design (cont'd)

- Special loading conditions may use “heavy duty” mixtures to resist rutting and shoving:
 - » Aggregate:
 - Dense gradations
 - Meets criteria for soundness, hardness, durability, abrasion resistance, and number of fractured faces
 - » Binder:
 - “Bumping” the grade of binder
 - Using a polymer-modified binder
 - Using a gap-graded mixture (e.g., SMA)
- Mixture enhancements in top lift only

Structural Thickness Design

- Similar to conventional HMA street and highway pavements
- Goal: Determine a suitable cross section that:
 - » Limits strain on subgrade
 - » Minimizes tensile strain in the HMA layer
- Common procedures
 - » AASHTO 1993 Pavement Design Guide
 - » AASHTOWare Pavement™ ME Design Software
 - » PerRoad Software



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Pavement Construction

Pavement Construction

- Similar to construction of conventional HMA facilities
- General items highlighted
 - » Traffic staging
 - » Subgrade preparation
 - » Base and subbase preparation
 - » Utilities
 - » HMA placement
 - » Acceptance



Subgrade Preparation

- Follow same procedures/specifications as for conventional construction
 - » Subgrade should be stable and capable of providing good support
 - » Expansive or frost heave susceptible soils should be
 - Removed and replaced
 - Addressed through stabilization
- For rehabilitation of existing facility, subgrade reworking typically not performed



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Base and Subbase Preparation

- Layers placed, trimmed and compacted similar to conventional HMA projects
- Rehabilitation of existing facility:
 - » Evaluate base/subbase for damage and ability to provide support
 - » Repair/replace as warranted



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Utilities

- Handled in the same manner as conventional HMA paving
- Handwork often involved in these areas



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HMA Placement

- Generally lane-at-a-time using standard paving equipment
- On multi-lane facilities, place first paving lane along outer perimeter of roundabout against previously placed curb and gutter
 - » Helps provide lateral confinement to the HMA layer
- Construct in multiple lifts



© 2011 Washington State DOT

HMA Placement (cont'd)

- Roundabout curvature might cause some restrictions to the haul trucks and techniques used to load the paver hopper
- May consider more maneuverable end-dump trucks and unload material directly to pavement hopper
- May consider using forms of vertical referencing instead of skis to achieve smooth alignment



© 2011 Washington State DOT

Segregation

- Can occur throughout paving process
 - » HMA production
 - » Loading/delivery
 - » Final laydown
- Results in:
 - » Reduced durability
 - » Reduced service lives
- A particular concern for coarse-graded mixtures with large maximum size aggregate
- Use typical agency practices to minimize segregation



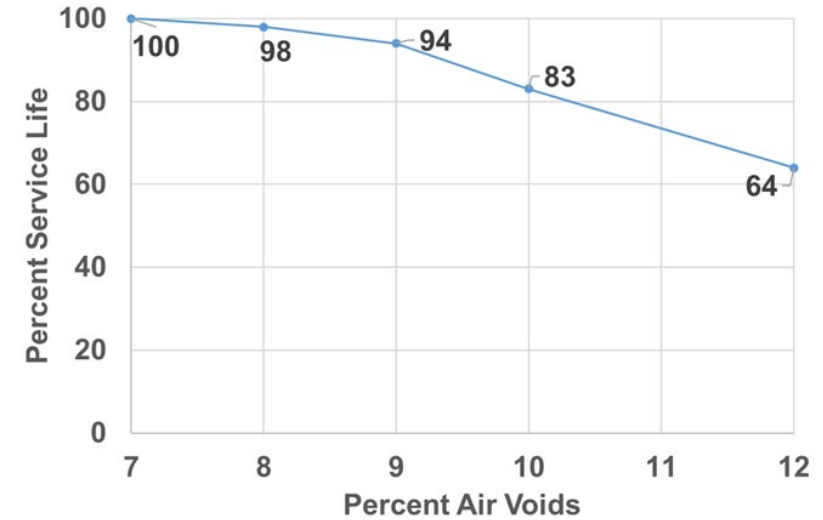
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Compaction

- Affects long-term performance of the pavement
 - » Increases resistance to fatigue cracking
 - » Increases resistance to permanent deformation
 - » Increases resistance to moisture sensitivity
 - » Increases resistance to oxidation



© After Linden, Mahoney, and Jackson 1989



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Compaction (cont'd)

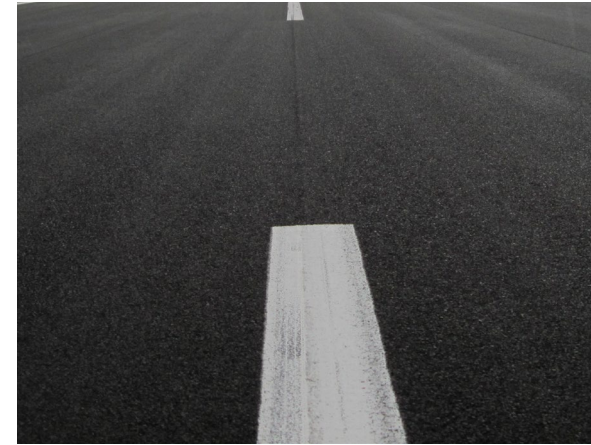
- Same as conventional HMA paving
 - » Vibratory steel wheel rollers
 - » Rubber-tired rollers
- No unique compaction considerations for roundabouts
 - » Follow appropriate roller patterns for uniform compaction
 - » Minimize overly tight turns by rollers that could potentially tear the mat



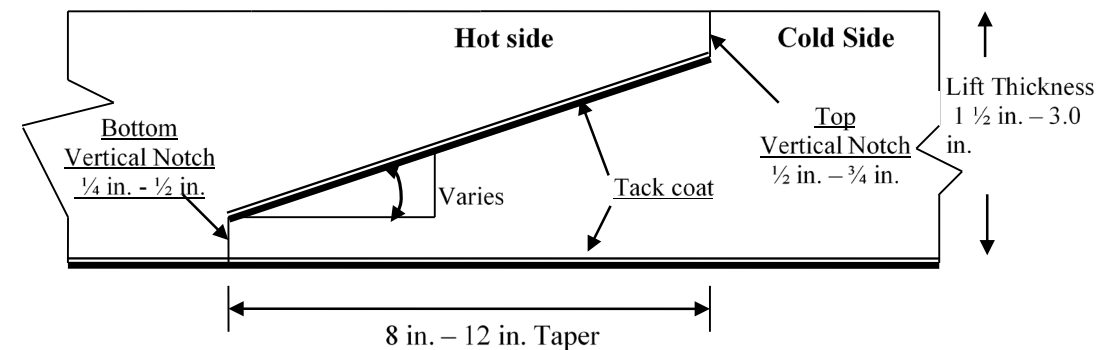
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Longitudinal Joint Considerations

- Dense/durable joints between HMA paving lanes
 - » Prevents intrusion of water and air to pavement system
 - » Prevents development of raveling and joint deterioration
- Employ agency practices for longitudinal joint construction
- Options:
 - » Wedge or notched wedge joint
 - » Echelon paving (multi-lane roundabouts)



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Acceptance

- Acceptance testing (e.g., thickness, density) as per the owner agency's conventional paving practices
- Pavement owner agency requirements should be followed
 - » No Federal requirements apply
- Smoothness can be checked with a 10-ft straight edge



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Summary

Summary

- HMAP most common pavement type used in roundabout construction
- HMAP roundabouts can offer:
 - » Low initial costs
 - » Rapid construction
 - » Easy future maintenance
- Owner agency practices for conventional HMA design and construction should be followed
- Consider special mixture design considerations for heavily loaded facilities



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Source: Pixabay

Jointed Concrete Pavement (JCP) Roundabouts

Transportation Research Board Webinar

Tom Van Dam

Jointed Concrete Pavements

- Most common concrete pavement type
- Slab sizes are typically short
 - » 18 to 24 times slab thickness
 - » Maximum joint spacing 15 ft
- Typically without mid-panel steel reinforcement
- Dowels used in transverse joints if $D \geq 8$ inches
- Tie bars commonly used at longitudinal joints



© 2009 ACPA

JCP Roundabouts

- JCP used for roundabouts in numerous States and around the world
- Used for all traffic volumes and loadings
- Constructed using conventional practices
- Layout and jointing are important considerations



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JCP Roundabouts

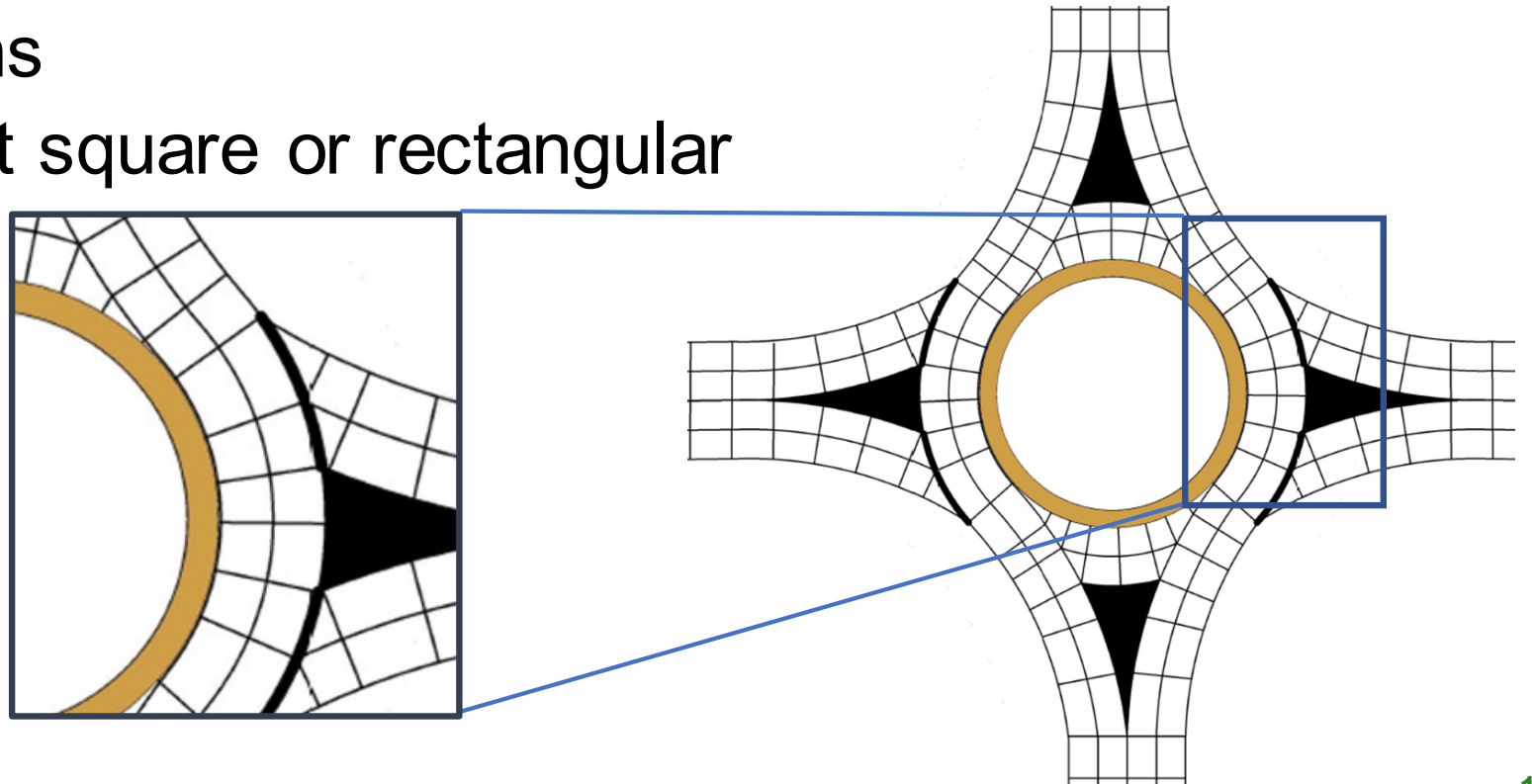


JCP Roundabout Typical Applications

- Potentially a good choice for single-lane and multi-lane roundabouts that incur heavy loadings
 - » Commercial vehicles
 - » Buses
- Concrete typically resists high shear stresses generated by turning tires

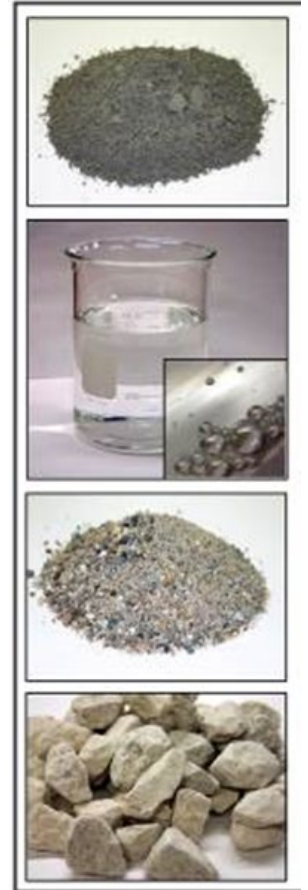
Limitations

- Establishing an effective jointing layout is important
 - » Takes more effort than conventional jointing due to tight curvature and varying lane widths
 - » Concrete slabs are not square or rectangular
 - Trapezoidal
 - Odd-shaped
 - Variable-width
 - “T”-intersections
- Rapid construction



Concrete Materials and Mixture Design

- Conventional concrete materials and mixtures
- Can use accelerated mixtures to meet early opening times
 - » Use accelerated mixtures only where needed
 - » Design accelerated mixtures to meet project-specific opening times (e.g., for a 3-day construction window, choose a mixture designed to be opened in 48 hours)
- Consider using optimized aggregate grading and reduced cementitious materials content to improve performance, lower cost, and reduce environmental impact



© 2016 Portland Cement Association

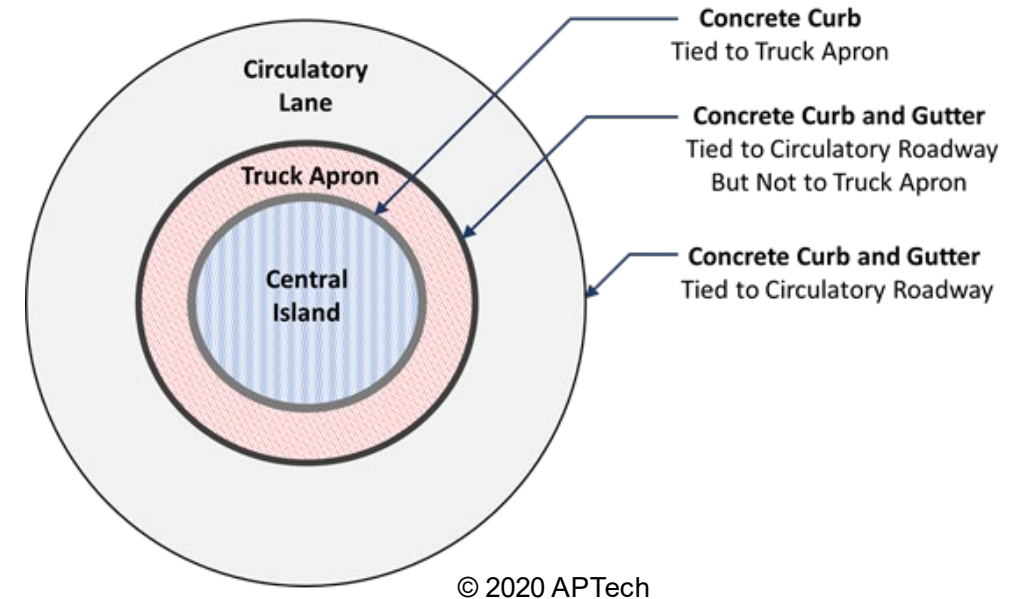
Structural Design Considerations

- Use the same structural design approach as for other concrete pavements
- Traffic may be higher on circulating roadway than on any one of the entering legs
- Use supporting layers consistent with local agency practice



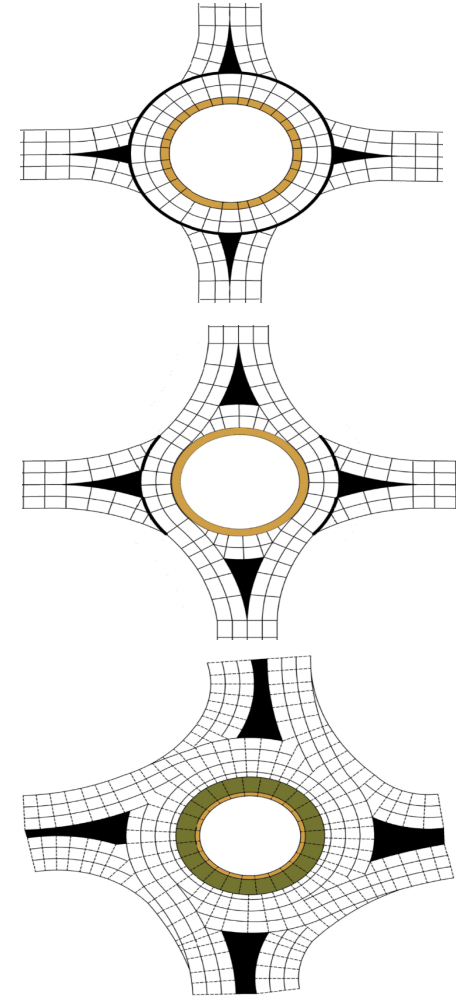
Jointing Considerations

- Develop jointing plan early in the design process
- Transverse joints in radial pattern
- Longitudinal joints concentric circles following curved centerline
- Tie curb and gutter to JCP in legs and circulating roadway
- Isolate truck apron from the mountable back of curb
- Isolate roundabout legs from the circulating roadway



Three Common JCP Roundabout Joint Layouts

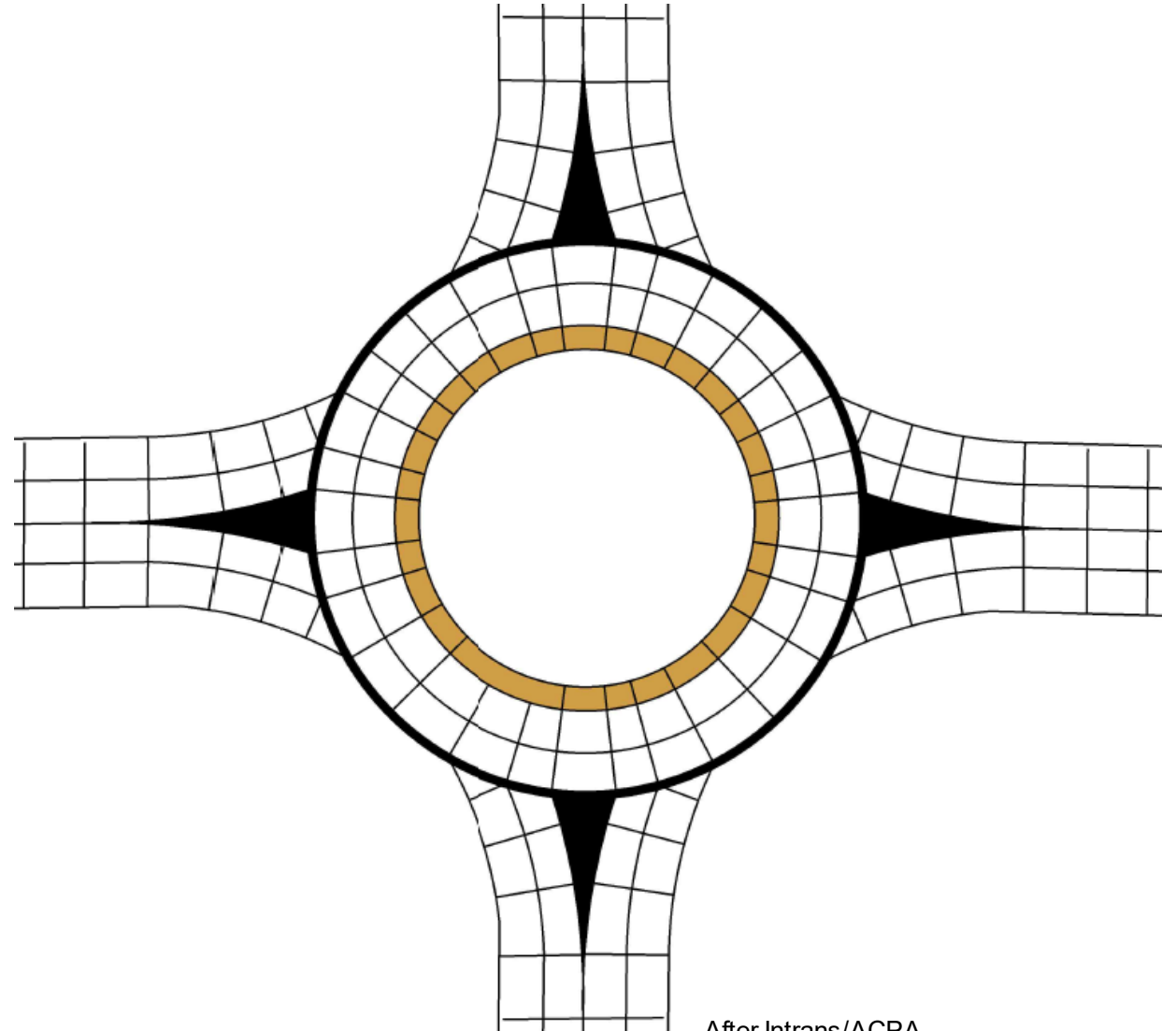
- Isolation
 - » Concrete joint pattern of the circulating roadway isolated from that of the legs
- Pave-through
 - » Concrete joint pattern of the legs continues through the circulating roadway to support slipform paving
- Pinwheel
 - » Concrete joint pattern of the circulating roadway continues through the exit legs



After Intrans/ACPA

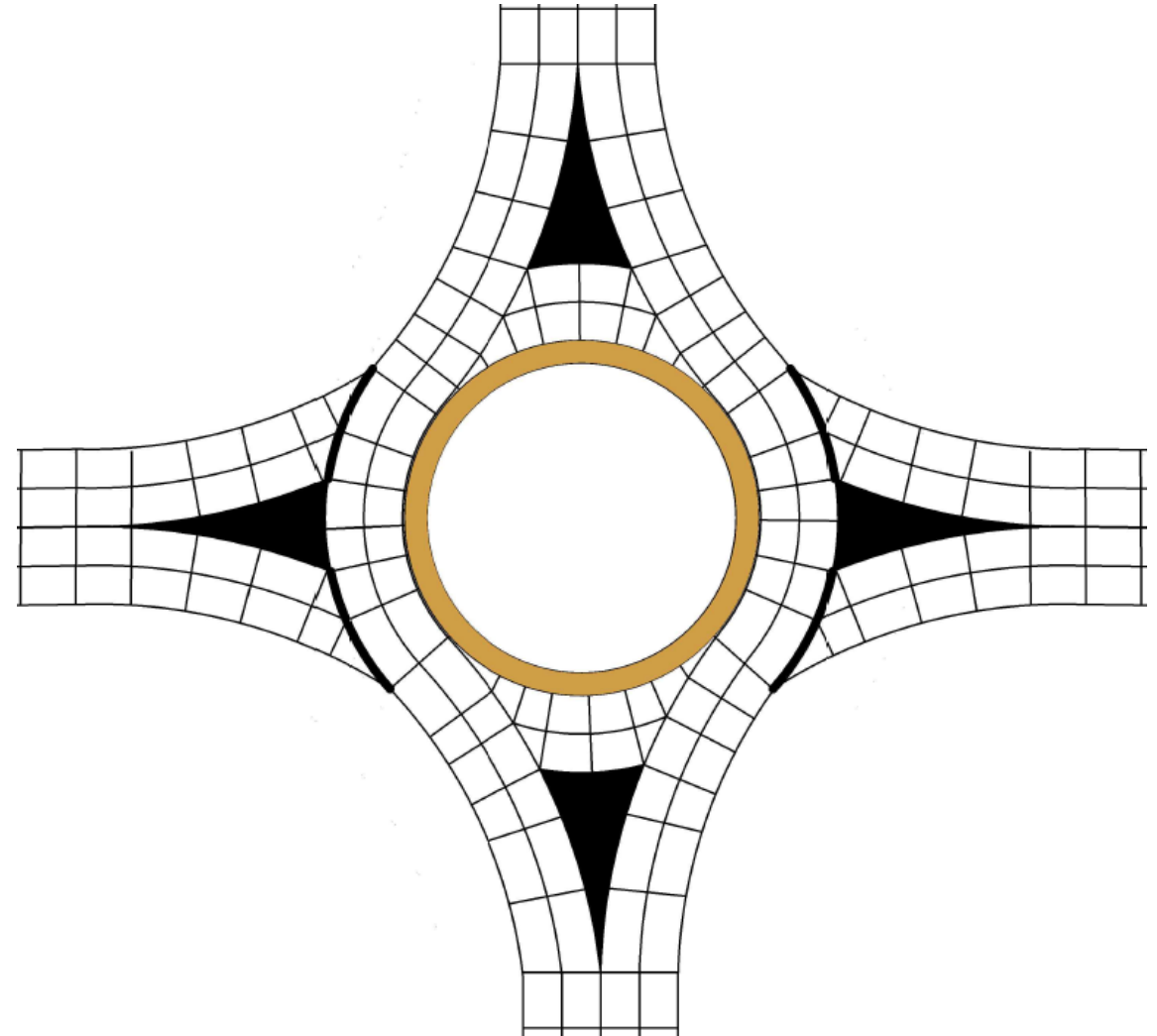
Jointing – Isolation

- Common with large roundabouts constructed under traffic detour
- Isolate outside of circulating roadway from legs



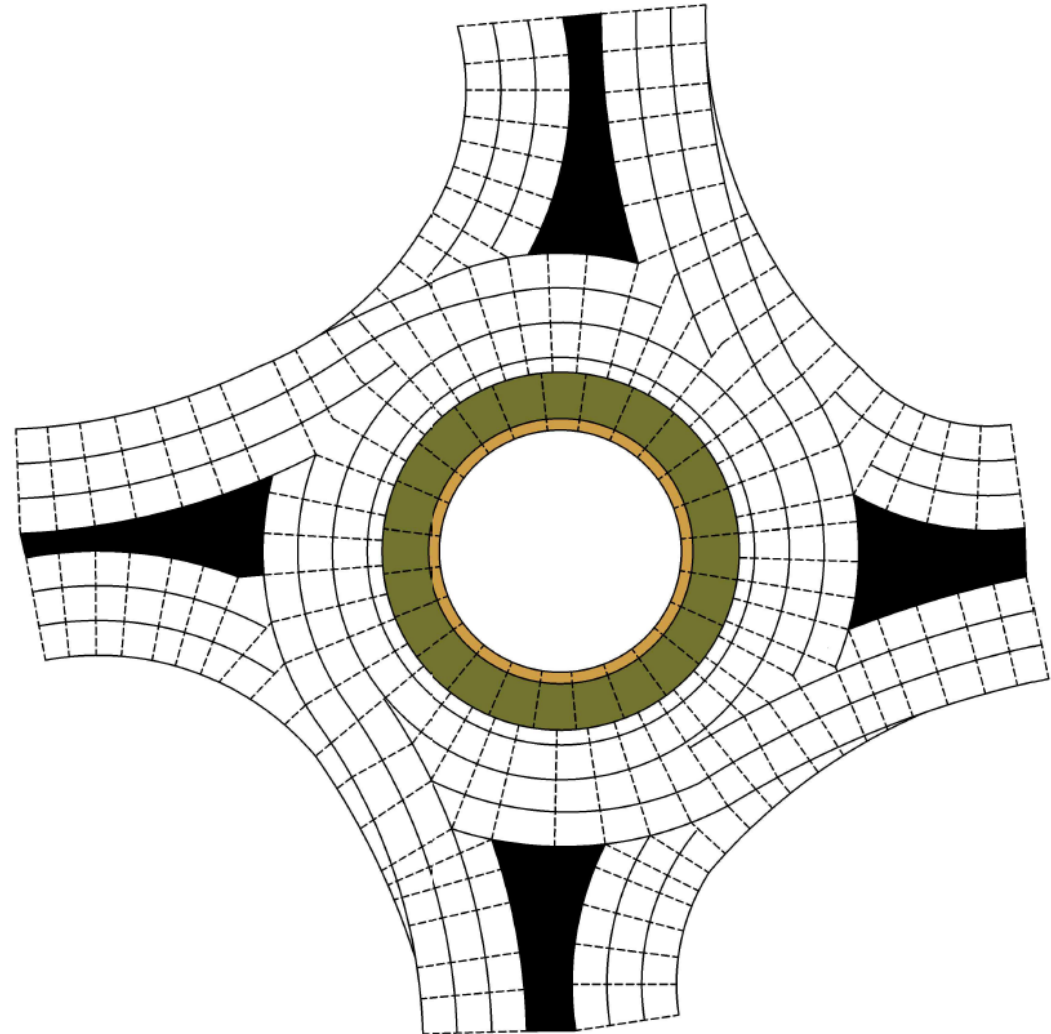
Jointing – Pave-through

- Facilitates the use of slipform paver
- Also can be designed to follow the direction that is expected to carry the heaviest traffic
- Pave-through concrete is isolated from the legs and other sections of circulating roadway



Jointing – Pinwheel or Spiral

- Concrete joints between the circulating roadway and all legs doveled or tied
- Used for multi-lane roundabouts



Slab Sizing and Jointing Suggestions

- Avoid designing slabs with any dimension greater than 15 ft
- Maximum joint spacing of 18 to 24 times slab thickness
- Avoid any dimension less than 2 ft
- Avoid slabs with length to width greater than 1.5:1
- Avoid “T” intersections of joints and “L-shaped” slabs
- Joints should meet or intersect in-pavement structures
- Avoid corners with angles less than 60 degrees

Odd-Shaped Slabs

- Try to keep odd-shaped slabs out of dominant traffic path
- Reinforce odd-shaped slabs
 - » Steel is designed to control cracking that occurs
 - 0.15 to 0.20 percent by cross-sectional area
 - Macrofibers an alternative



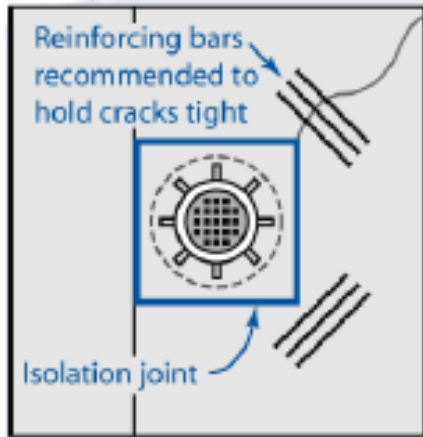
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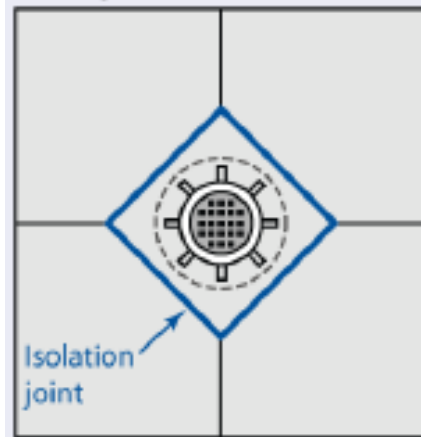
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Suggested Isolation of In-Pavement Structure and Utility Blockouts

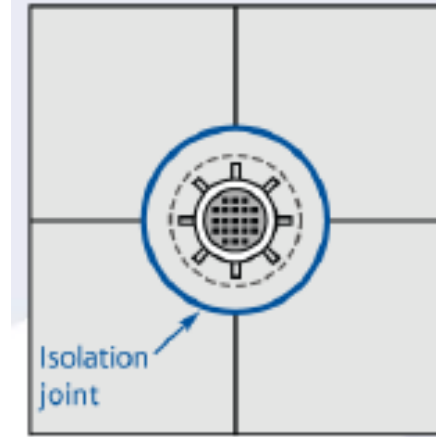
Square Manhole Boxout



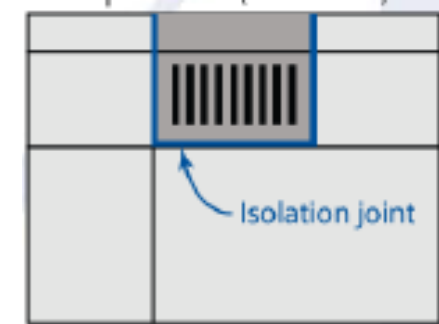
Diagonal Manhole Boxout



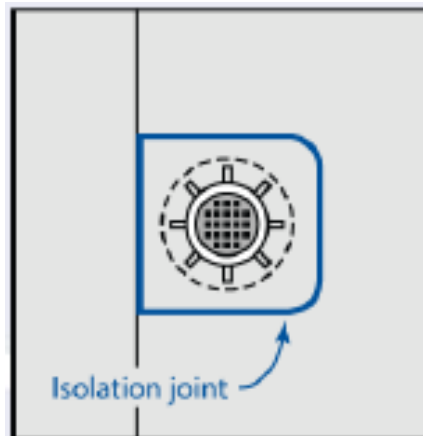
Circular Manhole Boxout



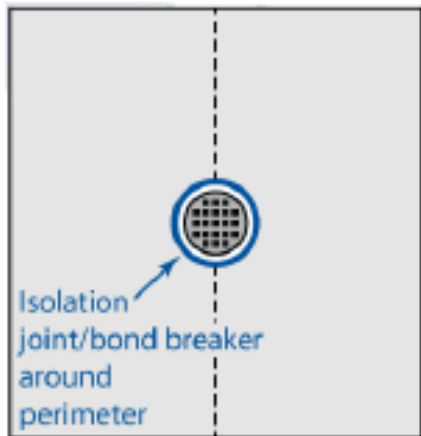
Square Inlet (No Boxout)



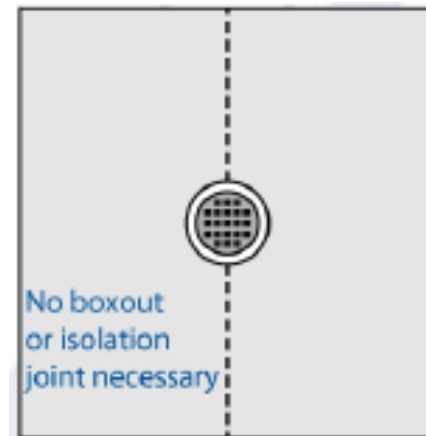
Square Boxout with Fillets



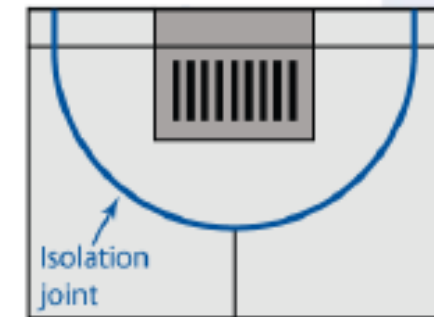
Manhole (No Boxout)



Telescoping Manhole



Round Inlet Boxout



Isolation of In-Pavement Structure Through Utility Blockout



Other Potential Design Considerations

Roadway Transitions

- Approach leg entries and exits should be JCP before transitioning to hot-mix asphalt pavement (HMAP)
- If access road is concrete, an isolation joint **should be** placed prior to last slab to reduce thrust force
- Transition between JCP and HMAP typically includes a thickened edge or sleeper slab



© 2007 ACPA

Traffic Staging

- Three possible options
 - » Route all traffic around construction zone
 - » Some traffic diverted away from construction zone
 - » Maintain full traffic during construction



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Subsurface Preparation

Subgrade

- Provides uniform support to the JCP
- Expansive and frost-susceptible soils typically addressed through various measures, such as:
 - » Chemical stabilization
 - » Removal/replacement
 - » Geosynthetics

Subbase and Base

- Subbase is commonly untreated granular material
- There are many suitable untreated and treated base materials
 - » Working platform during construction
 - » Uniform support in-service

Dowel Bars and Tie Bars



© 2007 ACPA



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Reinforcing Odd-Shaped Slabs

- JCP roundabouts typically have a number of odd-shaped slabs
- These should be reinforced to restrain cracking that may occur
- Steel should be positioned on chairs or dobies and terminated 6-inches from joint
 - » Steel should remain in position through construction



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Placement

- Slipform paving can be used for larger roundabouts
 - » Inner radius is greater than 26 ft
- Fixed form paving is very common for roundabouts
 - » Various pavers and screeds can be used
 - » Don't overwork the surface



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Summary

- JCP can be a candidate for roundabouts designed to carry heavy traffic
 - » Truck and/or buses
- Jointing layout
 - » Complicated by the curvature and changing lane widths associated with circulating roadway, truck apron, and entrance/exit lanes
 - » Results in trapezoidal slabs with variable width, odd-shaped slabs, and sometimes offsets creating “T” joint intersections
- Designer should provide a great level of detail for joint layout

And Always - Strive for Longevity





Roundabouts: Paving the Way to Safety

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

Presented on 11/17/2021 for the
TRB AKP20, AKC20 and AKD80 Committees

Intersection Safety Importance

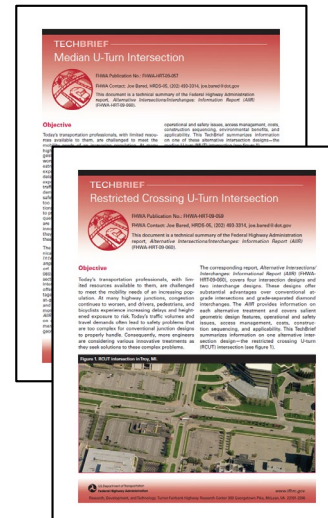
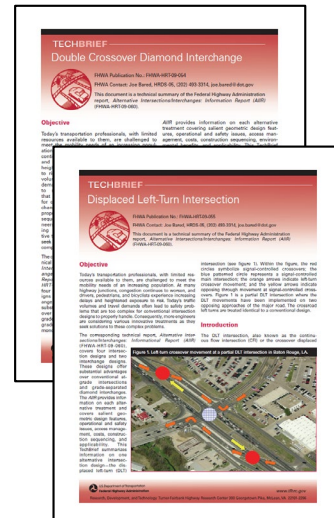
- ↳ Just over **one-quarter** of all traffic related fatalities in the United States are related to intersections
- ↳ About **one-half** of all traffic related serious injuries are related to intersections



Innovative/Alternative Intersections

Essential ingredients:

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



“cho·re·og·ra·phy”

Source: FHWA

Innovative Intersection Benefits

SAFETY

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

MOBILITY

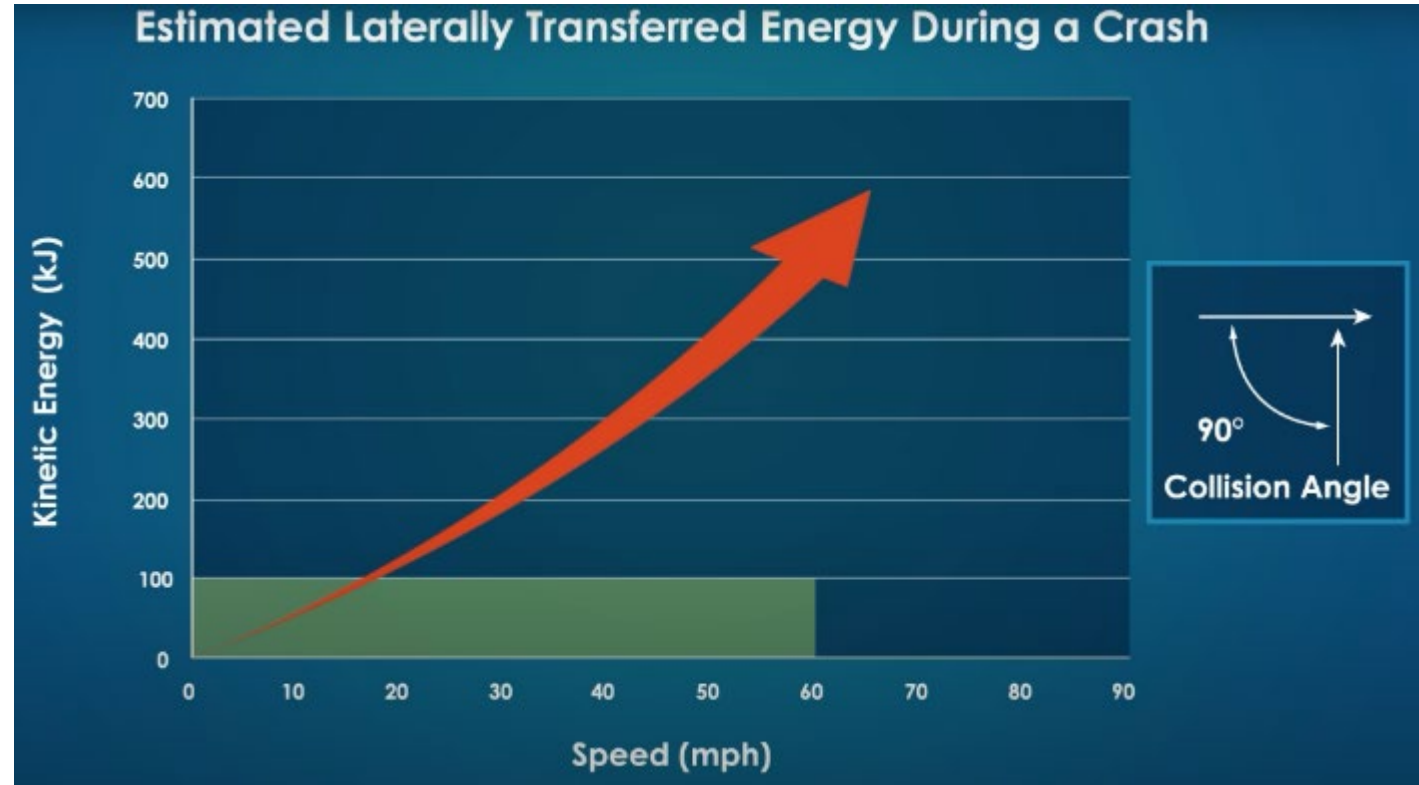
- Shorter trip duration
- Better trip reliability
- Reduced congestion
- Opportunities for walking and biking

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

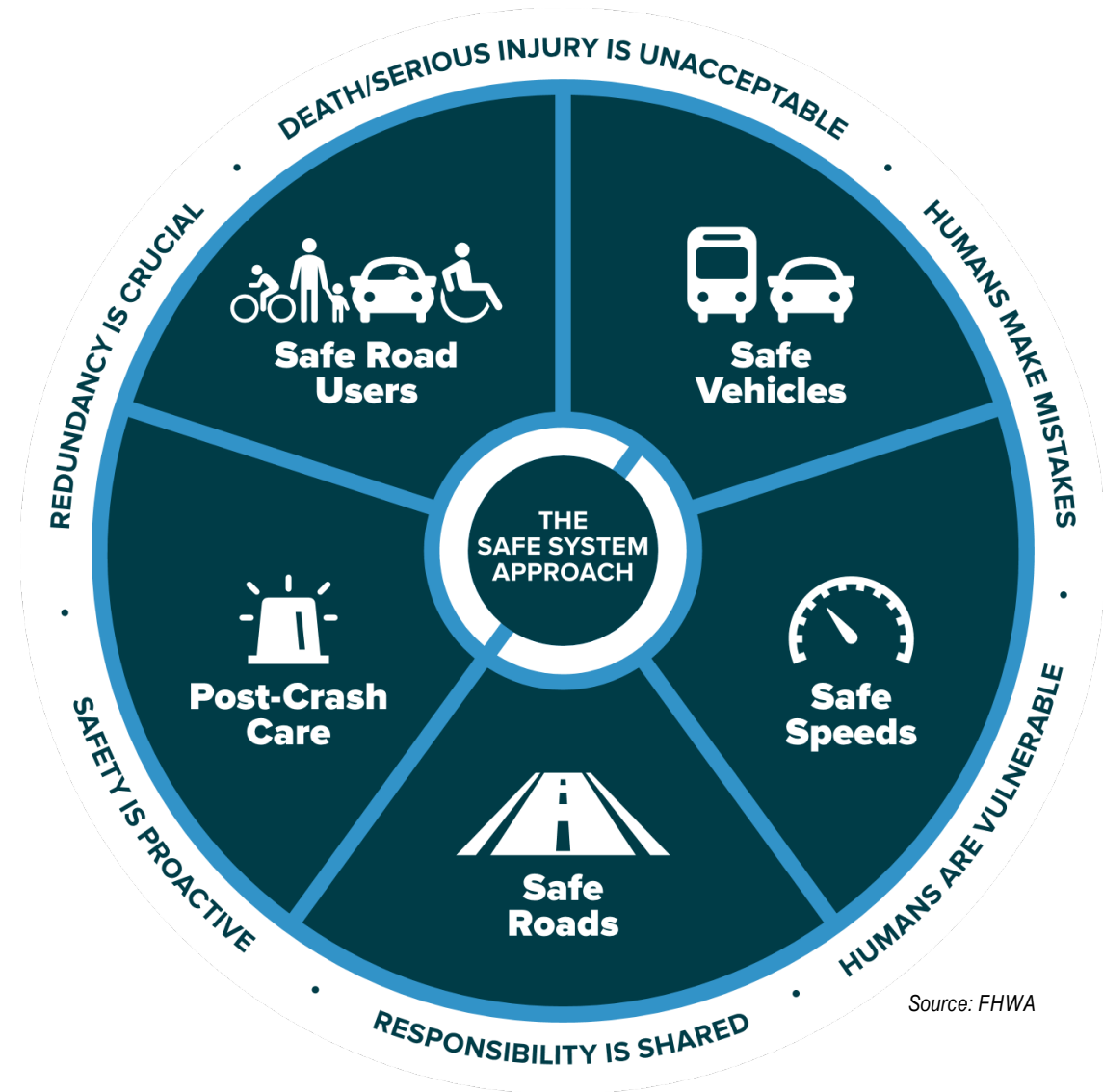
The **Safe System Approach** aims to eliminate fatal and serious injuries for all road users by:



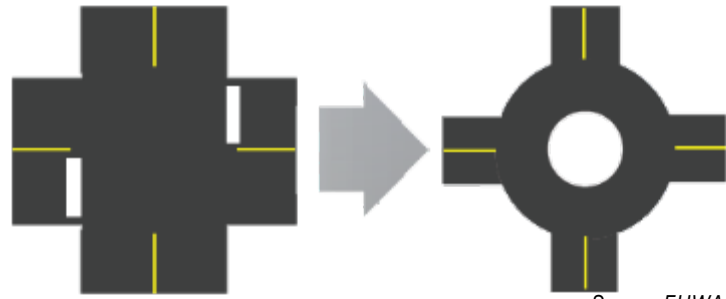
Accommodating human mistakes



Keeping impacts on the human body at tolerable levels



Source: FHWA



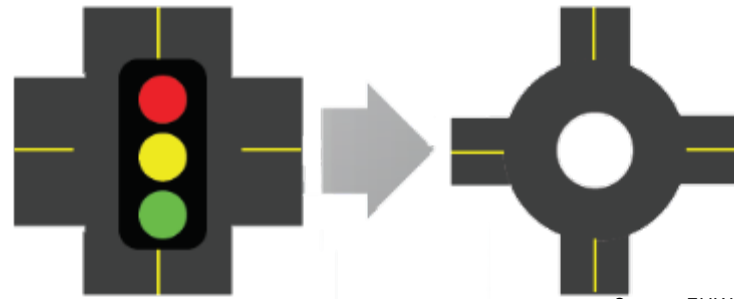
Source: FHWA

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

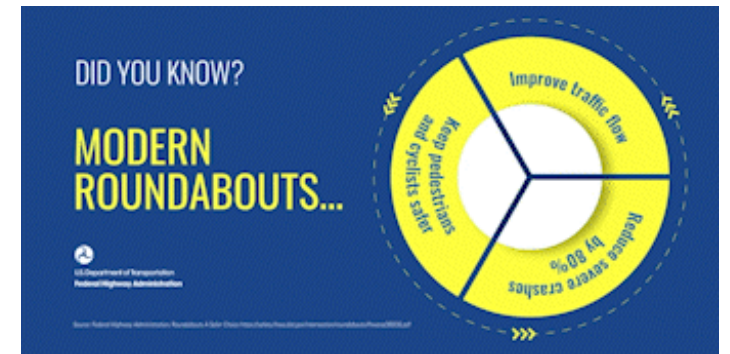
78%

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

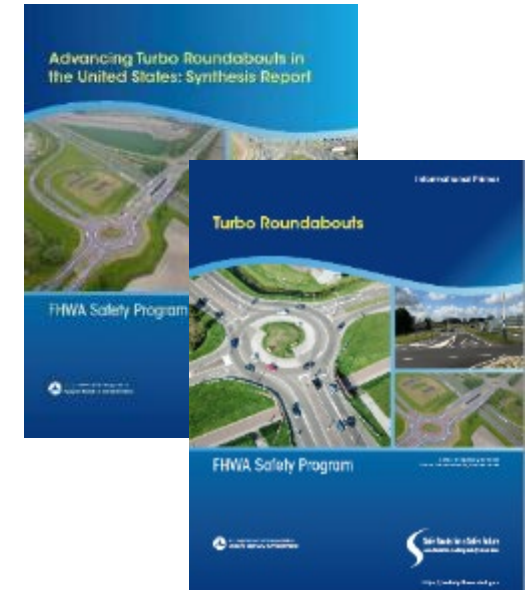


Source: Jeff Shaw, FHWA

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

Roundabouts are Adaptable

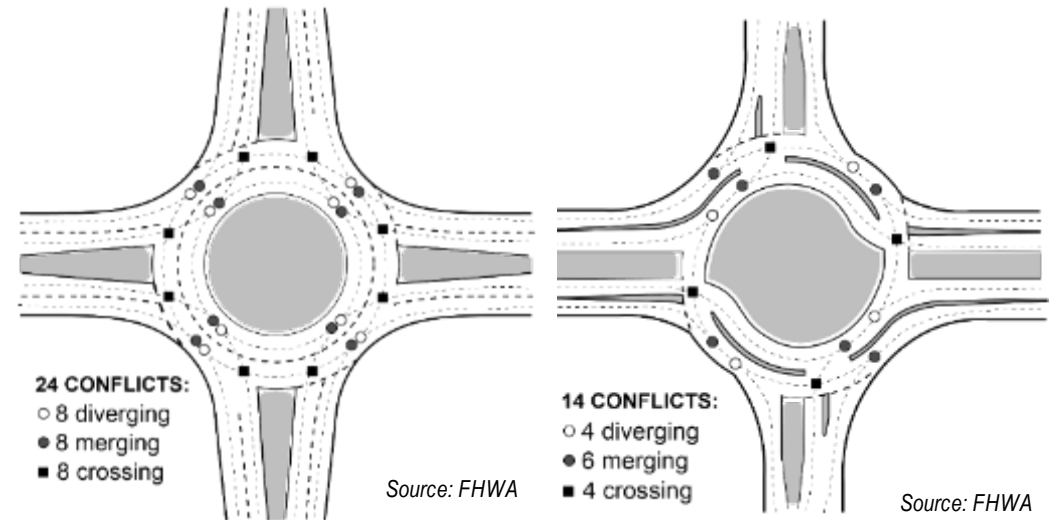
- ◀ May be single lane, multilane, or mini/compact designs
- ◀ Emerging multilane design is the “turbo”



Source: FHWA



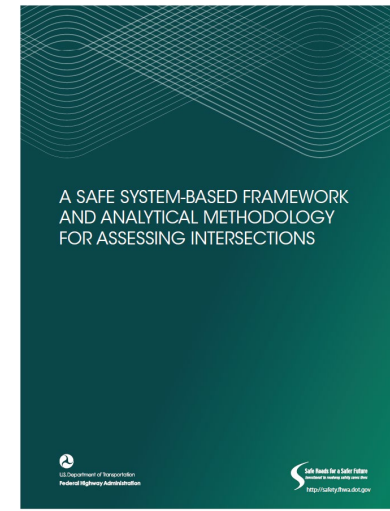
Source: FHWA



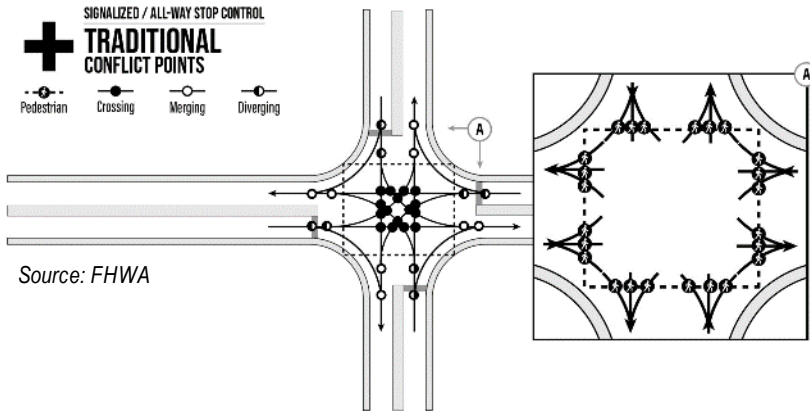
Source: FHWA

Source: FHWA

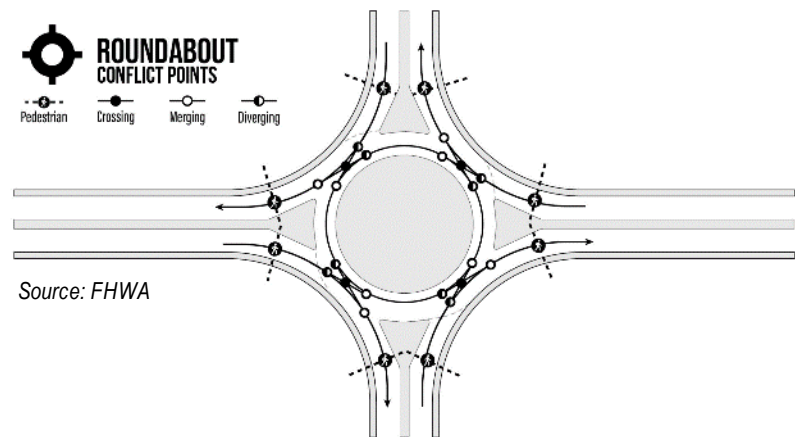
Safe System Intersections



Source: FHWA

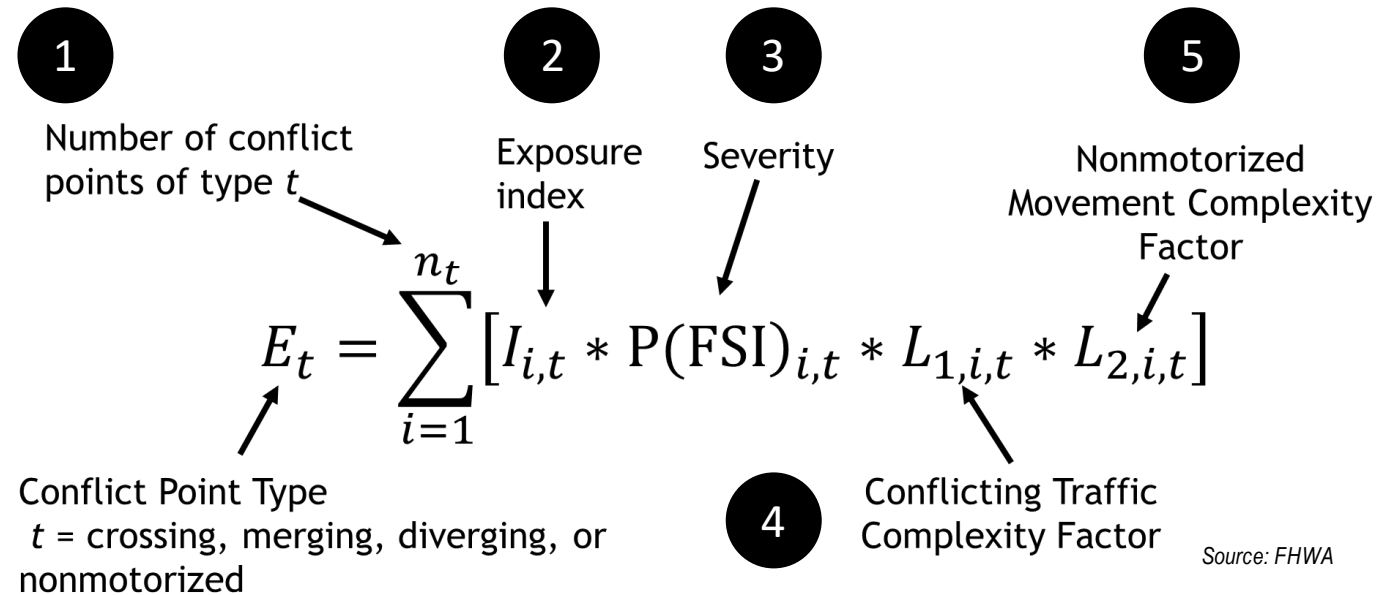


Source: FHWA



Source: FHWA

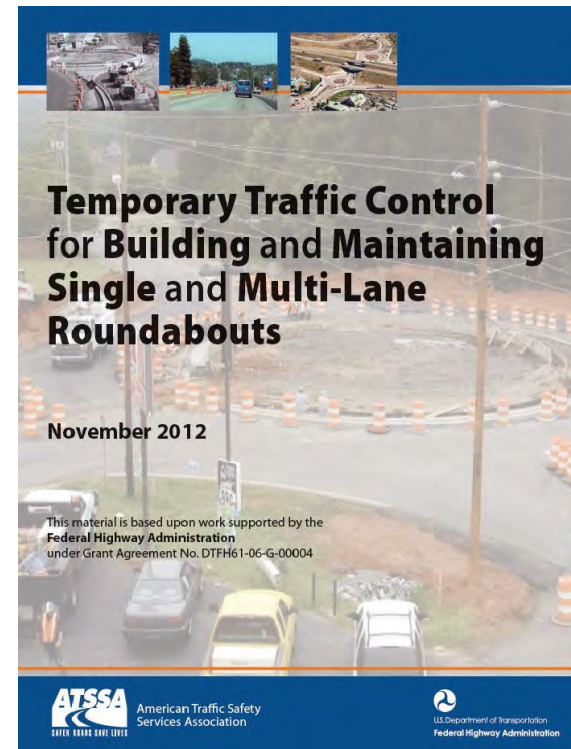
“Built on Innovative Intersection Principles”



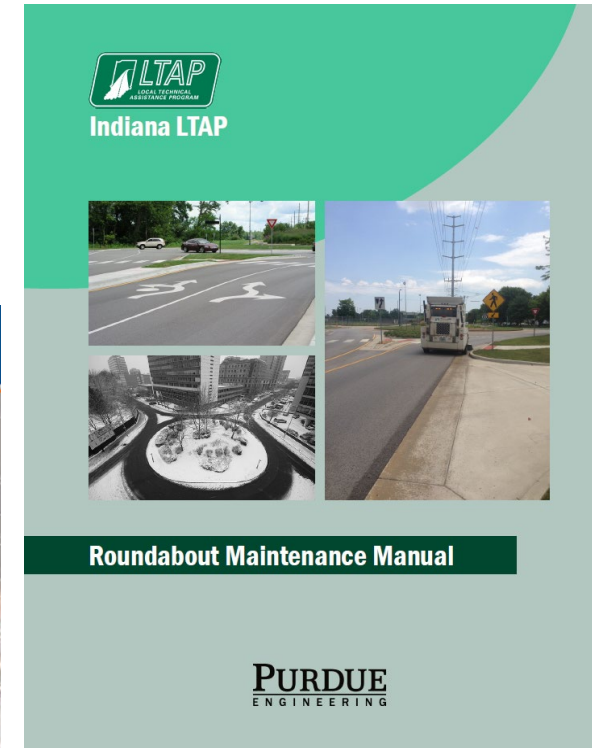
Source: FHWA

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!



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Other TRB events for you

- *December 16:* TRB Webinar: Hit the Ground Running—Innovative Concrete Pavements in Roundabout Design
- *December 8:* TRB Virtual Careers in Motion Networking Fair

<https://www.nationalacademies.org/trb/events>

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