Tech Brief

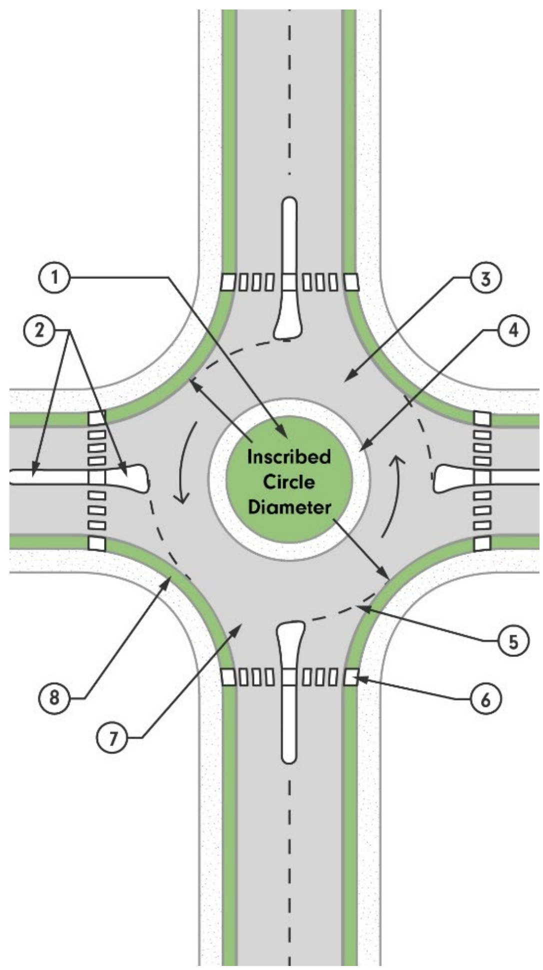
MARCH 2021 FHWA-HIF-20-080

Jointed Concrete Pavement (JCP) Roundabouts

INTRODUCTION

General Background on Roundabouts

A roundabout is a form of circular intersection in which traffic travels counterclockwise (in the United States and other right-hand traffic countries) around a central island and in which entering traffic yields to circulating traffic (Rodegerdts et al. 2010). Compared with signalized and stop-controlled intersections, modern roundabouts provide better overall safety performance, shorter delays and shorter queues, better management of speed, and lower management and operation costs while also adding aesthetic value (FHWA 2010). Figure 1 presents a general schematic of a roundabout, along with a brief description of some of the key design features.



1. **Central Island** – Raised area around which the traffic circulates.
2. **Splitter Island** – Raised or painted area on the approach used to separate entering and exiting traffic, control entering traffic, and accommodate pedestrians crossing the roadway.
3. **Circulatory Roadway** – Curved path used by vehicles to travel around the central island in a counterclockwise direction.
4. **Truck Apron** – Part of central island that facilitates wheel tracking of large vehicles.
5. **Entrance / Yield Line** – Marks the point of entry to the circulatory roadway. Also functions as a yield line in the absence of a separate yield line.
6. **Accessible Pedestrian Crossings** – Provided before the entrance / yield line; splitter island is cut to allow access for pedestrian, wheelchairs, strollers, and bicycles in accordance with ADA requirements.
7. **Exit** – Marks the point of exit from the circulating roadway.
8. **Landscape Buffer** – Separates vehicular and pedestrian traffic and guides pedestrians to designated crossing locations.

Figure 1. Key roundabout design features.

U.S. Department of Transportation
Federal Highway Administration

Image sources (from top):

Roundabouts are typically classified into three basic categories: mini, single lane, and multilane (FHWA 2010). Most roundabouts constructed in the United States are single lane (roughly 70 percent) and multilane (28 percent) (Rodegerdts 2017). As shown in figure 2, a cross slope of 2 percent away from the central island is typical for the circulatory roadway on single-lane roundabouts (WSDOT 2019). This not only helps in surface drainage, but also promotes safety by raising the height of the central island and improving its visibility, encourages lower circulating speeds, and minimizes breaks in the cross slopes of the entrance and exit lanes (FHWA 2010).

Various pavement types can be used in the construction of roundabouts, including hot-mix asphalt pavement (HMAP), jointed concrete pavement (JCP), continuously reinforced concrete pavement (CRCP), and precast concrete pavement (PCP). This Tech Brief describes the application, design, and construction aspects of JCP roundabouts.

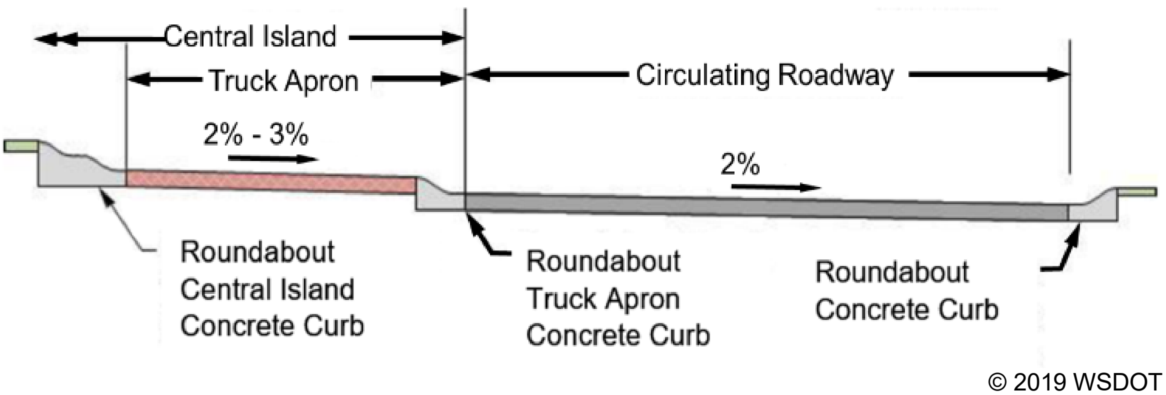


Figure 2. Typical circulating roadway section with truck apron.

Background on JCP Roundabouts

JCP designs are used for roundabout construction in numerous states and around the world. JCP performs well for roundabout systems exposed to heavy traffic loadings, including commercial vehicles and buses (Rodden 2009). While much of JCP roundabout construction uses conventional concrete pavement construction practices, there are several unique aspects, particularly the layout and jointing of the JCP panels. The curved and circular travel lanes of roundabouts are most easily accomplished using trapezoidal panels, often with dowels and tie bars. This can be accomplished in much the same way that jointed panels are routinely installed on curved highway ramps.

APPLICATION AND EFFECTIVENESS

Typical Applications

JCP is typically used for single-lane and multi-lane roundabouts that incur heavy loadings from commercial vehicles and buses. These types of vehicles can subject the pavement surface to high shear stress as they pass through the relatively tight curves in a roundabout configuration (Stet, van Leest, and Jurriaans 2004; McMullen 2016). JCP provides good resistance to this type of stress, making it an attractive choice for roundabout applications, and is an effective pavement type when a long-term solution that minimizes future maintenance and traffic disruption is needed (Rens 2013; McMullen 2016).

Limitations

A critical challenge with the use of JCP pavements for roundabouts is establishing an effective jointing layout that addresses the curvature and changing lane widths inherent in the design of the circulating road, truck apron, and entrance and exit lanes (see figure 1). The tight curvature and varying lane widths result in slab configurations that are not square and may be subjected to restraint that results in uncontrolled cracking. Specifically, the joint layout should address trapezoidal slabs with variable width, odd-shaped slabs on entrance and exit lanes, and, at times, joint offsets resulting in "T" intersections that increase the risk of sympathy cracking. Other issues include choosing the proper joint types between the circulating roadway and the inside and outside curbs as well as with the truck apron. Consequently, JCP roundabout designs benefit from consideration of such details as slab size, use of load transfer devices, placement of isolation joints, and reinforcement details for odd-shaped panels.

There is often a perceived need to accelerate roundabout construction to minimize traffic disruption. This can be a challenge for JCP as adequate curing time is needed under the prevailing climatic conditions for the concrete to gain sufficient strength to support traffic. In these cases, accelerated construction methods often are utilized with high-early-strength concrete materials, which may introduce the potential for premature failures.

In addition, it is important to incorporate utilities through proper location, jointing, and isolation to minimize uncontrolled cracking and ensure good long-term performance.

PAVEMENT DESIGN CONSIDERATIONS

Important JCP design considerations for roundabouts include planned traffic staging, concrete materials and mixture selection, structural thicknesses, jointing, panel reinforcement, roadway transitions, and the truck apron dimensions and design.

Traffic Staging

Three general traffic management strategies may be employed during the construction of roundabouts: (1) all traffic routed around the construction zone, (2) some traffic diverted away from the construction area, and (3) full traffic maintained during construction (Rodegerdts et al. 2010). As one example, the Georgia Department of Transportation provides construction phasing options (GDOT 2019):

- Closure of the intersection with a traffic detour for part or most of construction duration.
- Partial detour by closing the crossroad or one leg of roundabout.
- Short-term closure of the intersection with a traffic detour.
- Construction of the roundabout under traffic for undivided 2-lane roadway.
- Construction of the roundabout under traffic for divided 4-lane roadway.
- Construction of a roundabout off alignment.

Concrete Materials and Mixture Design

Concrete materials and mixture design are the same for roundabouts as for any JCP roadway. Detailed information on proportioning concrete mixtures is available from the American Concrete Institute (ACI) (ACI 2017a) and the Portland Cement Association (PCA) (Kosmatka and Wilson 2016). Consideration should be given to the use of colored and/or stamped concrete for the truck apron and splitter islands to help delineate these features from the circulating roadway and legs of the roundabout.

If construction is to be done during a short-term closure or under traffic, project phasing may involve the use of accelerated construction techniques, including the use of high-early-strength concrete (see ACI 2019). Most State highway agencies (SHAs) have specifications for high-early-strength concrete. General characteristics of such mixtures include higher-than-normal cementitious contents, relatively low water-to-cementitious materials ratios, and the use of ASTM C150 (AASHTO M 85) type III high early-strength cement. If sections of the JCP roundabout are to be opened to traffic within a few hours of placement, an alternative cement, such as a calcium-sulfoaluminate or calcium-aluminate cement, can be considered. These generally involve the use of mobile mixers.

Structural Thickness Design

The slab thickness design for JCP roundabouts is no different than for conventional street or highway pavements. Special consideration should be given to the traffic patterns in the circulating roadway because those sections may have higher traffic than any of the entering roadway legs. Non-binding pavement thickness design methods for JCP roundabouts include (Ferrebee 2015):

- AASHTO 1993 Pavement Design Guide (most common design method used by State DOTs, but not required under FHWA regulations).
- AASHTOWare Pavement™ ME Design software with consideration of local calibration.
- ACPA StreetPave 12 software as incorporated in PavementDesigner.org.

According to the American Concrete Pavement Association (ACPA) (ACPA 2005), JCP thicknesses for roundabouts typically range from 5 to 10 inches, depending on the design traffic, subgrade support conditions, and concrete properties. As with any JCP, the support for the concrete slab is provided by subbase and base layers and the underlying subgrade and is characterized by the composite modulus of subgrade reaction (k-value). The type and thickness of the subbase and base are most often selected based on recommendations provided by the owner-agency. Typical subbase/base materials include granular materials and stabilized (cement-treated or asphalt-stabilized) base materials (Hein et al. 2017). The subbase/base should provide adequate support for construction equipment.

Jointing

A concrete pavement jointing plan typically is developed early in the design process to support the overall design of traffic staging and construction phasing. Moreover, an effective jointing plan is critical to the successful construction and long-term performance of the JCP roundabout. A resource on concrete jointing practices is available from FHWA (2019), which offers the following points related to jointing JCP roundabouts.

Typical Layouts

Three common joint layouts for JCP are referred to as isolation, pave-through, and pinwheel as shown in table 1. Some key features of all types include (ACPA 2005; WisDOT 2018):

- Use a radial pattern for transverse joints in the circulating roadway and truck apron with longitudinal joints being concentric circles.
- Transverse joints in legs should be perpendicular to slab edges (or curb and gutter). Longitudinal joints should follow the curved centerline alignment and meet the end of the nearest transverse joint on the circulating roadway (except for isolation layout type).
- Tie curb and gutter to the associated JCP (e.g., to legs or circulating roadway). Do not tie the truck apron to the circulating roadway curb and gutter.
- Isolate the truck apron pavement from the circulating roadway at the back of curb.
- Isolate roundabout legs from the circulating roadway pavement (doweled expansion joints are sometimes used in lieu of isolation joints at these locations).

Considerations for Slab Sizing

It is important to establish slab size constraints before developing joint layouts. ACPA (2005) and FHWA (2019) provide the following considerations:

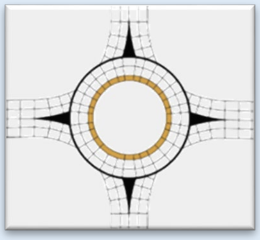
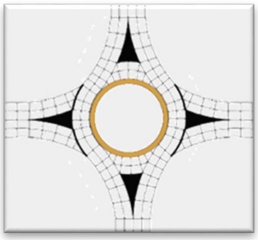
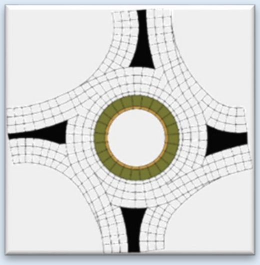
- Avoid designing slabs with any dimension longer than 15 ft.
- Maximum joint spacing of 18 to 24 times the slab thickness, with lower values selected for construction on stiffer (stabilized) bases.
- Avoid slabs with any dimension less than 2 ft.
- Avoid slabs with length to width aspect ratios greater than 1.5:1.

Joint Types and Locations

Joint types and locations are presented in table 2 along with typical features. In addition to the above slab sizing criteria, ACPA (2005) provides additional voluntary and nonregulatory considerations for joint layout:

- Match existing joints or cracks when possible to avoid “T” intersections of joints.
- Joints should meet or intersect in-pavement structures (e.g., manhole, utility boxes).
- Avoid creating slab corner angles measuring less than 60 degrees (accomplished by dog-legging joints to intersect perpendicular to the curve arc).
- Avoid slabs with interior corners (L-shaped slabs).
- Minimize use of odd-shaped slabs and reinforce those that cannot be avoided.

Table 1. Common joint layout types for JCP roundabouts.

Type	Joint Layout		Typical Application
Isolation	The concrete joint pattern of the circulating roadway is isolated from that of the legs.		Large roundabouts constructed under full traffic detour.
Pave-through	The concrete joint pattern of the legs continues through the circulating roadway to support slipform paving and/or to follow the direction that is expected to carry the most traffic. This pave-through concrete is isolated from the other legs.		When faster construction is warranted and/or when there is a predominant movement for heavier traffic conditions.
Pinwheel or spiral	The concrete joint pattern of the circulating roadway continues through the exit legs. The concrete joints between the circulating roadway and all legs doweled or tied.		Multi-lane roundabouts, not used for single lane roundabouts.

Source: InTrans (2018).

Table 2. Common JCP joint types used in roundabouts.

Joint Type	General Locations	Typical Features
Doweled	Transverse joints in circulation roadway and entrance/exit legs.	• Dowel bar diameter ranges from 1.0 to 1.5 inches, depending on slab thickness and traffic loading. • Dowel bar lengths are typically 15 or 18 inches. • Bars are typically spaced on 12-inch centers with no bar placed within 12 inches of a longitudinal joint. • Epoxy-coated or corrosion-resistant dowel bars should be used in corrosive environments.
Tied	Longitudinal joints in circulation roadway and entrance/exit legs (curb is typically tied to circulatory roadway and entrance or exit legs).	• Tie bars are typically No. 4 or 5 bars (0.5- to 0.625-inch diameter) with typical length of 30 inches. • Bars are typically spaced on 30-inch centers with no bar placed within 15 inches of a doweled transverse joint.
Isolation	Between truck apron and back of curb, legs in the isolation roundabout, and to isolate structures.	• Typical width is 0.5 to 0.75 inch. • Compressible filler material designed for this purpose for the entire depth of the slab. • Common to use thickened edge design for circulating roadway. • Can be doweled when adjoining pavements are in the same direction.

Joint Design Process

ACPA (2005) provides a six-step voluntary and nonregulatory process to develop a concrete jointing plan for JCP roundabouts. This is outlined below and shown in figure 3 using the isolation layout example (ACPA 2005), which is not regulatory in nature.

1. Draw pavement edge and back-of-curb lines along with locations of any in-pavement structures.
2. Draw all lane lines (or longitudinal joints) on the circular portion and on the legs.
   Pave-through type: determine the pave-through roadway.
   Isolation type: do not extend the lane lines through the circle.
3. Add the transverse joints radiating out from the center of the circle and extend the joints through the back of the curb and gutter. Check panel dimensions against recommended limits for trapezoidal slabs.
4. Add transverse joints on the legs at locations where there is a change of width in the pavement and extend the joints through the back of the curb and gutter.
5. Add transverse joints between and beyond the transverse joints added in the previous step. Ensure joints are spaced evenly and in accordance with joint spacing constraints.
6. Make joint adjustments for in-pavement fixtures to minimize odd-shaped and small triangular slabs.

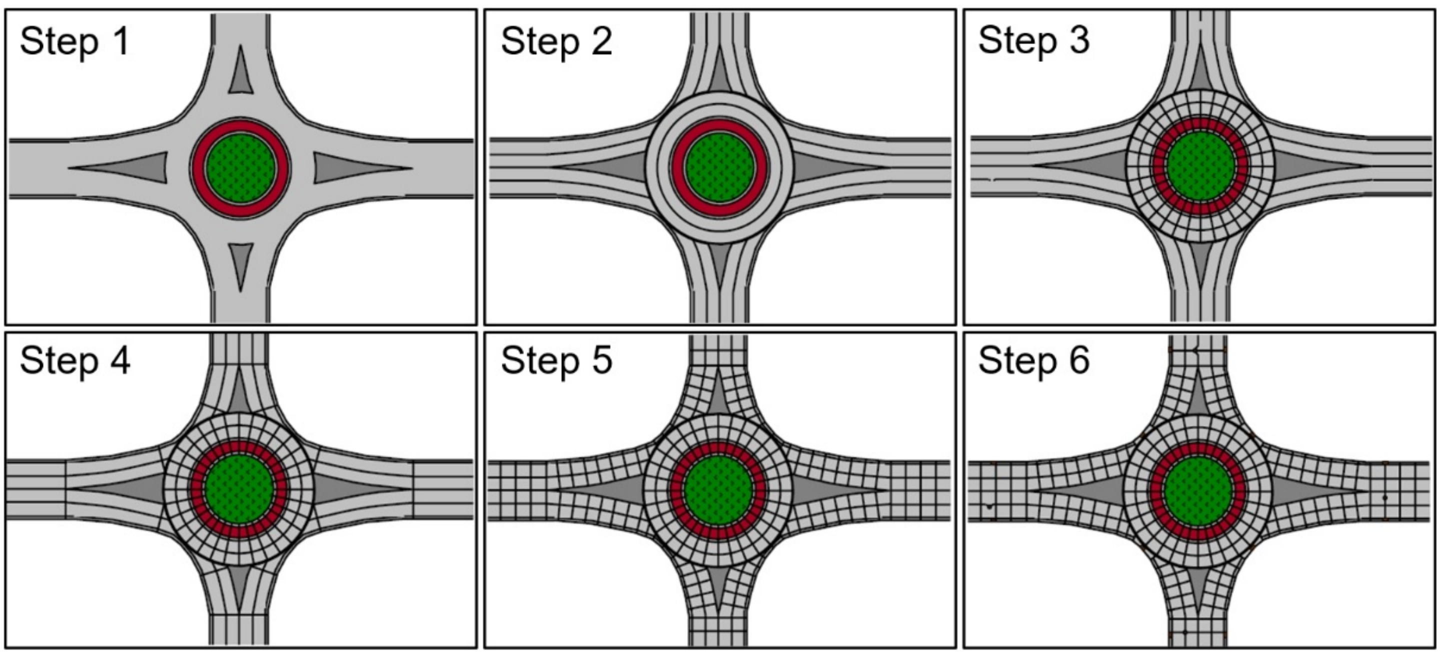


Figure 3. ACPA 6-step process for joint layout using isolation layout example.

Odd-Shaped Slabs and Utility Blockouts

Although one overall goal of the joint design process is to minimize odd-shaped slabs, a small number of non-conforming slabs (e.g., slabs that are not square, slabs with acute corner angles, or slabs with an excessive length-to-width aspect ratio) may be inevitable (figure 4). Slabs with angles less than 60 degrees should not be placed in heavy vehicle wheel paths. Slabs with high aspect ratios (length-to-width greater than 1.5:1) or that possess an acute angle are more susceptible to cracking.

The risk for cracking can be mitigated by using steel reinforcement (e.g., mesh or small diameter bars) or fiber reinforcement. Reinforcement with steel mesh or small diameter rebar is typically used at 0.15 to 0.20 percent of the cross-sectional area of the slab. It should be placed in the upper half to the upper third of the slab and should not be carried through the joints. Alternatively, macrofibers can be used. A typical range of steel fiber dosage is 54 to 81 lbs/ft^3 (Rens 2013), whereas synthetic macrofibers are typically dosed at 3 to 7 lbs/yd^3, depending on the recommendations of the fiber manufacturer and impacts on concrete workability.

a. Slab with acute angle.

b. Odd-shaped panels in transition pavement.

Figure 4. Examples of odd-shaped slabs.

Adjustments to concrete joint layout are often used to accommodate in-pavement utility structures, such as shown in figure 5 (ACPA 2007). Important considerations include (ACPA 2007): (1) when a joint is within 3 ft of an in-pavement structure, adjust the joint so that is passes through the structure; (2) isolation joints should be at least 0.5 inches wide and filled with a compressible material; and (3) boxouts should provide at least 1 ft of clearance between the fixture and the isolation joint. Figure 6 provides an example of a utility structure boxout and associated jointing.

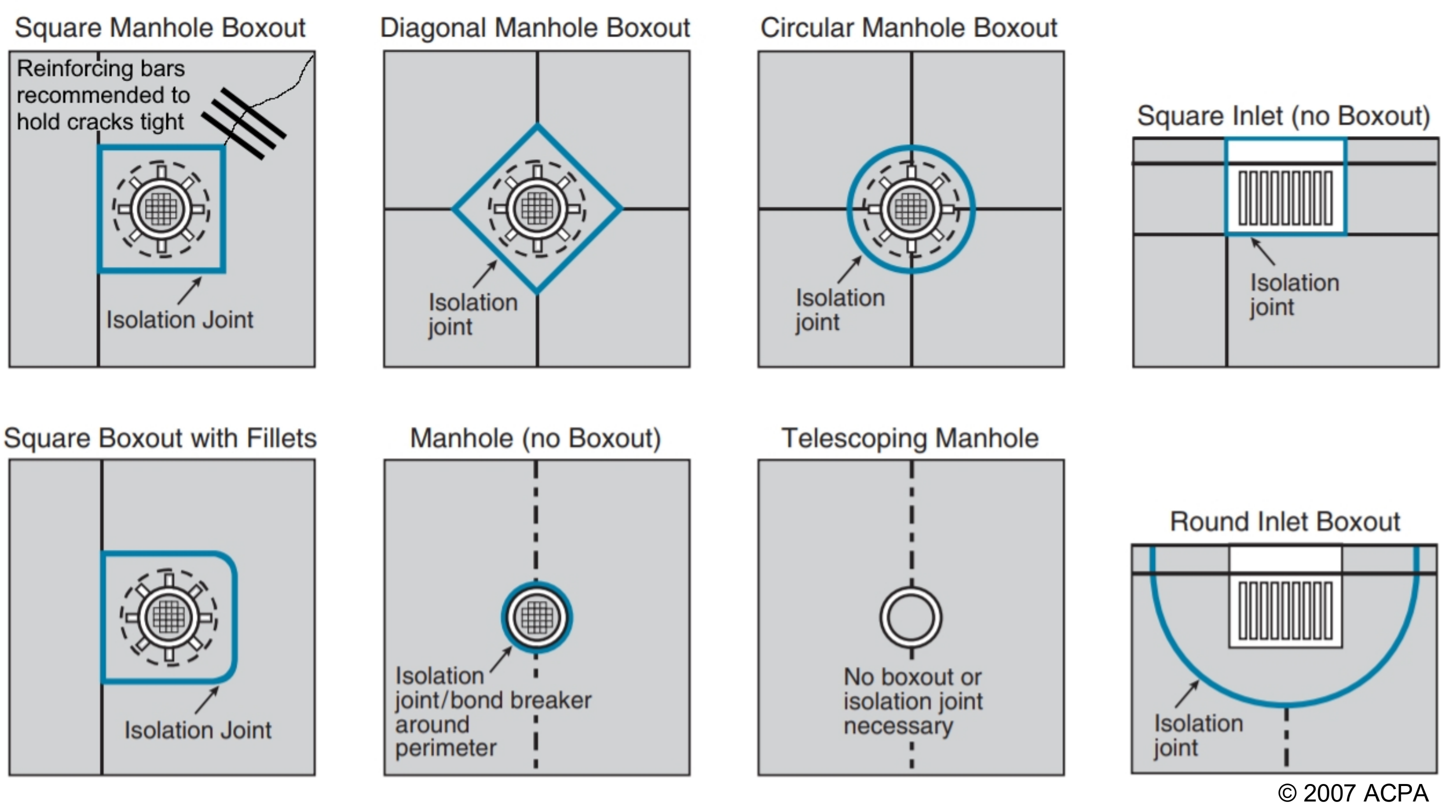


Figure 5. Suggested use of isolation joints for in-pavement structures.

Figure 6. Example of a utility structure boxout and associated jointing.

Roadway Transitions

When one or more roundabout legs transition to HMA pavement, high stress concentration is generated at the approach leg entries and exits. Therefore, these should also be JCP before transitioning to HMAP. An isolation joint placed prior to the last slab can help to reduce thrust forces between JCP leg slabs and adjacent HMAP on connecting roads (Rens 2013). The approach legs are anchored to the circulating roadway pavement for pave-through and pinwheel joint configurations to keep continuity and the transition should have matching joints.

Truck Apron

As shown in figure 1, the truck apron is the area between the circulating roadway and center island whose purpose is to provide a paved surface for wheel tracking of trailer axles as long trucks pass through the roundabout. Colored concrete or stamped patterns are several options used to differentiate the appearance of the truck apron from the circulatory roadway; but in some cases, these may discourage truck drivers from using the truck apron (ITE 2008).

The truck apron may be CRCP, JCP, or in some cases block pavers, with an expansion joint used to isolate it from the back of curb of the circulatory pavement. If the truck apron is JCP, some standard detail drawings (e.g., SDD 13C18-e, WisDOT 2018) show the truck-apron transverse joints without dowels, which may satisfy most design situations. State or local highway agencies may choose not to place dowels in the truck apron if it is assumed that few if any trucks could traverse the transverse joints. Alternatively, dowels could be used along the full length of transverse joints in the truck apron, especially for smaller-diameter roundabouts, if it is assumed that a significant number of trucks could traverse them. Similarly, a logical design detail for transverse joints in the truck apron could also show dowels along the outer half of the transverse joint if this is assumed to be the portion of the transverse joint that could be subjected to a significant volume of truck traffic.

PAVEMENT CONSTRUCTION

Many aspects of the construction of JCP roundabouts are similar to conventional concrete pavement street construction, although there are some significant differences in layout, techniques, and phasing. The following subsections highlight important JCP roundabout construction factors.

Subgrade Preparation

The subgrade provides uniform support to the JCP. Problematic soils, including those that are expansive or susceptible to frost heave, are typically addressed by removing and replacing the soil or through the proper use of chemical stabilization (e.g., using lime or cement) to reduce swell potential. Some state and local highway agencies may specify use of geogrid or geotextile for cases of very low subgrade strength or when the potential for migration of fines into engineered layers exists.

Subbase and Base Preparation

Subbase is commonly an unstabilized, granular material that is used to improve drainage and/or provide protection against expansion or heave. There are many suitable base materials for JCP, including unstabilized crushed aggregate, asphalt-treated base (ATB), cement-treated base (CTB), and lean concrete. The main objective of the base is to provide uniform support to the concrete pavement and construction equipment. The base material is typically placed wider than the specified concrete width to ensure uniform slab support at the pavement edges and to provide support for concrete forms or slip-form paver tracks. ACPA (2008) and Hein et al. (2017) provide information on the proper construction of subbases and bases.

Dowel Bars and Tie Bars

Dowel bars are used to ensure good load transfer across joints designed to accommodate only horizontal movement. They should be placed and aligned along the joint in accordance with specified locations and tolerances (vertical and horizontal) to allow the concrete to freely expand and contract. Misalignment may result in high stress concentrations and slab cracking. If used, dowel baskets should be securely fastened to the base material to prevent movement during paving operations. Typical dowel bar considerations used in roundabout design and construction are described in a number of publications (ACPA 2010; ACPA 2017; Taylor et al. 2019; FHWA 2019):

- Dowel bars are typically smooth cylindrical bars with diameter ranging from 1 to 1.5 inches, depending on slab thickness and traffic loads. They are placed at the mid-depth of the slab on 12-inch center-to-center spacings across transverse joints. They should not be placed within 6 inches of the slab edges and placements within 1 ft of the slab edges should be avoided.
- For roundabouts, dowels at contraction joints are most often placed using dowel baskets. For construction joints, they are drilled into the existing slab and anchored using a grout or epoxy material.

Plate dowels may be an attractive alternative to conventional cylindrical dowels because they provide load transfer from slab to slab while minimizing lateral restraint. Information on selecting the size and spacing of the plate dowels is available from ACI (ACI 2017b). Plate dowels come in various configurations; manufacturer's recommendations should be followed on sizing and placement. Corrosion protection is advised if the plate dowels are to be used in areas subjected to deicer applications.

In concrete roundabouts, deformed tie bars are often used to tie the interior concrete curb and gutter of the truck apron to the circulatory lane (see figure 7). Tie bars are also used to tie the truck apron to the concrete curb of the central island and to tie the outside curb/gutter to the outside circulatory lane. The tie bars are used to maintain alignment and restrain movement at tied "longitudinal" contraction and construction joints. Typical tie bar considerations during construction include (ACPA 2017):

- Tie bars are placed at mid-depth of the slab across the joint. These are typically No. 4 or No. 5 bars, 30 inches long, and spaced on 30-inch centers.
- Tie bars can be placed and aligned during concrete placement using various means including positioned on chairs or baskets, through proprietary systems that attach to formwork, the use of a tie bar inserter if the pavement is slipformed, or manually drilled into the existing slab and anchored with a grout or epoxy material.

It is possible to construct the roundabout without tie bars at these locations. This is because slab drifting or migration is unlikely to occur since the pavement is constrained by its geometric layout and by the dowel bars provided in the transverse joints. The resulting free edge condition of untied longitudinal joints may lead to slight increases in the thickness of the slabs used in the circulatory lane.

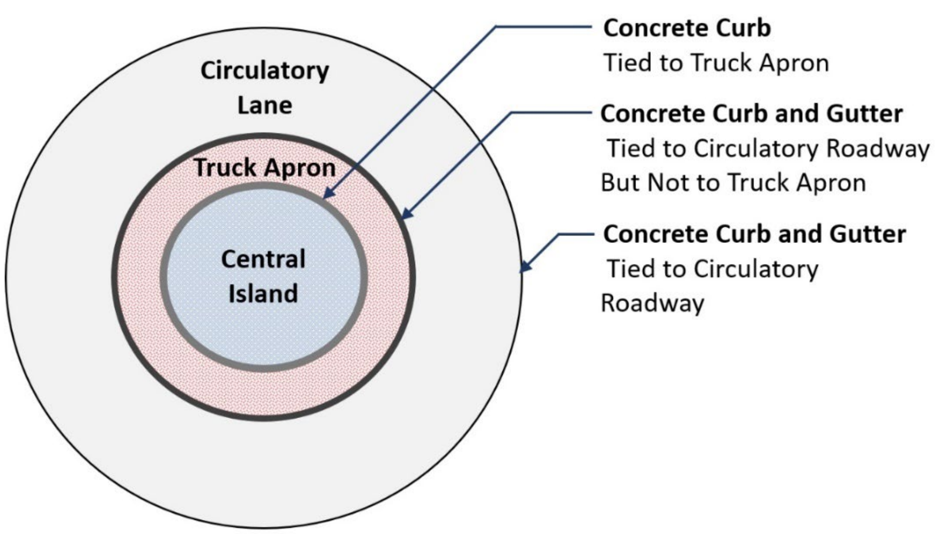


Figure 7. Tie bar locations for concrete roundabout designs.

Figure 8 provides examples of dowel bar and tie bar placement in the outer lane of a circulating roadway (Ferrebee 2015).

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a. Dowel bar placement.

© 2015 ACPA

b. Tie bar and dowel bar placement.

Figure 8. Example dowel bar and tie bar placement within circulating roadway.

Reinforcing Odd-Shaped Slabs

Due to their unique configuration, JCP roundabouts can produce a significant number of odd-shaped slabs, and reinforcement may be needed to restrain cracking. If steel reinforcing mesh or bars are used, they should be held in place on chairs or dobies and terminated approximately 6 inches from the joint. Care should be exercised during concrete placement and consolidation to avoid stepping on the steel and forcing it to the bottom of the slab. Figure 9 provides an example of steel reinforcement placed in an odd-shaped slab.

Isolating Utilities

In-pavement structures can be intersected by a joint or placed in the middle of a slab as long as it is isolated and reinforced, as shown in figures 5 and 6. During construction, any drains or inlets should be protected before paving to prevent concrete from getting into the drainage system.

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Figure 9. Example of steel reinforcement in an odd-shaped slab.

Placement

The placement of the concrete can be done using a slipform paver for large roundabouts. For smaller roundabouts, it is common to use hand placement and forms, a paver or vibratory screed, and hand-inserted internal vibrators. The paving sequence ultimately depends on the method chosen and contractor preference.

Paver Placement – Slipform Paving

For large-radius roundabouts and long approach legs, slipform paving can be an effective method of placement (figure 10). According to European experience, the slipform paver method is suitable for roundabouts with an inner radius greater than 26 ft (Kramer and Jurriaans 2014).

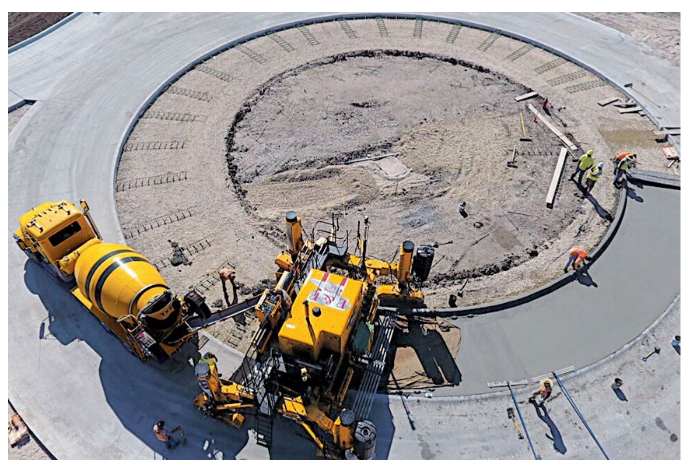

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Figure 10. Slipform paving a roundabout.

All slipform paving involves extensive upfront planning. The following items merit discussion in a pre-paving meeting:

- Paver entrance and exit paths, tracking during placement, and the sequence for starting and stopping placements.
- Number and sequence of placements.
- Width of paving and features included (e.g., one lane and curb).
- Truck access and concrete discharge method.
- Maintenance of traffic.

Hand Placement – Fixed Form Paving

Various pieces of equipment can be used for fixed-form paving, including pavers that span the forms, vibratory screeds, and roller/bridge deck finishers. Forms used for radial placements are typically wood, but plastic forms are another option. Forms should be adequately braced at the edges and base to provide support for placing and finishing equipment and to resist bulging during concrete placement.

The spreading of the concrete mixture is first performed with the ready-mix truck chute or with hand tools. If hand tools are used, shovels are preferred since they cause the least segregation. With the concrete distributed on grade, the concrete should be leveled. A vibratory screed is most often used since it is easy to adapt the vibrating screed to the width of the paving work. Figure 11 shows an example of a single roller-tube vibratory screed.

After pouring and placing the concrete, internal vibration using at least one handheld vibrator for every 5 ft of width of concrete is recommended (Rens 2013). Hand-held vibrators are vertically inserted and withdrawn, leaving the head of the vibrator inserted for 5 to 15 seconds. Concrete should not be moved using hand-held vibrators.

Hand placement of roundabouts also involves upfront planning. The following items merit discussion in a pre-paving meeting:

- Number and sequence of placements.
- Specification and securing of forms.
- Width of paving and features included (e.g., one lane and curb).
- Truck access and concrete discharge method.
- Maintenance of traffic.

Figure 11. Single roller-tube vibratory screed used on a roundabout.

Entry and Exit Transitions

Whether the joint layout is an isolated circle or a pave-through, entry and exit transitions involve extra considerations as these are the locations where large stresses occur due to vehicle braking and acceleration. Some considerations for approach legs are:

- Use of a sleeper slab under the isolation joints between the approach road and roundabout to provide better load transfer at the isolation joint (Rens 2013).
- Use of isolation joints in the approach slabs if the access road is a concrete pavement (Rens 2013).

- Use of a thickened edge at isolation joints without load transfer devices or sleeper slabs, or where the JCP terminates into an asphalt pavement.

Surface Finishing and Curing

The pavement surface texture is an important characteristic, particularly as it relates to surface friction. As vehicle speeds in roundabouts are typically relatively low, adequate surface friction is commonly obtained by using broom finishing or an exposed aggregate finish.

Curing practices should follow the State or local highway agency approved methods. Similarly, joint sawing should be done at the specified locations using approved equipment (i.e., either early-entry or conventional saws) and at the appropriate time, as specified by the State or local highway agency.

Acceptance

Acceptance testing requirements (e.g., thickness, strength) and thresholds should follow the State or local highway agency practices. Smoothness is typically checked with a 10-ft straight edge to look for vertical deviations that fall within an agency-specified range (e.g., 0.12 to 0.5 inches) for corrective grinding or outside a specified threshold (e.g., more than 0.5 inches) for slab replacement.

SUMMARY

JCP is a suitable candidate for roundabouts designed to carry heavy traffic (commercial vehicles and buses) as it provides good resistance to high shear stress generated by these vehicles as they pass through the relatively tight curves inherent in roundabouts. The most critical challenge with the use of JCP for roundabouts is establishing the jointing layout, which is complicated by the curvature and changing lane widths associated with the circulating road, truck apron, and entrance and exit lanes. The tight level of curvature results in slab configurations that are prone to restraint and sympathy cracking. Specifically, the joint layout addresses trapezoidal slabs with variable width, odd-shaped slabs in entrance and exit lanes, and at times, joint offsets resulting in “T” intersections that increase the risk of sympathy cracking. Other issues include choosing the proper joints between the circulating roadway and the inside and outside curbs as well as with the truck apron. Consequently, JCP roundabout designs benefit from consideration of such details as slab size, use of load transfer devices, placement of isolation joints, and reinforcement details for odd-shaped panels.

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