R&T UPDATE
Concrete Pavement Research & Technology

Concrete Roundabouts

Rigid Pavement Well-Suited for Increasingly Popular Intersection Type

In certain areas of the United States, traffic engineers are recognizing the benefits of using roundabouts instead of traditional signalized intersections. These benefits include reduced accident rates, reduced delay time, and lower speeds, to name a few.

Today's roundabouts are different than traffic circles. When designed and striped correctly, roundabouts offer better traffic flow and safety characteristics than most other intersection types. The vehicles on the entering roadways must yield to traffic in the circulating roadway. This ensures that there is no gridlock in the roundabout.

Why Concrete for Roundabouts

The roundabout designer has a choice of pavement type for roundabouts; concrete or asphalt. Concrete roundabouts are long-lasting and easy to maintain, because concrete does not push, shove, or rut under the turning motion of heavy vehicles around the intersection. Concrete provides a long-term fix, and is well-suited to areas where future disruption to traffic must be kept to a minimum.

In high-traffic areas, where safety is a priority, concrete will stand up to the pounding of heavy traffic. It does not require periodic rehabilitation, such as overlays, every 5 to 10 years like asphalt does. And drainage characteristics are preserved over time, because concrete does not rut, shove, or succumb to potholes. Additional benefits like good skid resistance and lighter colored, more reflective paving material make concrete the better choice.

Concrete pavements can be constructed more quickly than asphalt pavements, because they are placed in one pass of the paver instead of multiple lifts. Concrete mixtures can also be easily colored and textured to differentiate traffic patterns and distinct areas of the intersection.

Design

The two primary design aspects for any intersection construction project and for roundabouts in particular, are pavement thickness design and jointing system design.

In most pavement thickness design procedures, designing the pavement structure requires, at minimum, determining the following factors:

1. ***Concrete Properties –*** Flexural strength or modulus of rupture, MR; and modulus of elasticity, E.
2. ***Support Conditions –*** Strength of the subgrade, or subgrade-subbase combination (modulus of subgrade reaction, k).
3. ***Desired Life –*** Design period, which is typically 20 years, but may range from less than 5 to more than 50 years.
4. ***Expected Traffic –*** The weights, frequencies, and types of truck axle loads that the pavement will carry during the design period.
5. ***Design Features –*** Use of dowels for load transfer at transverse joints, and provision of edge support along slab edges.
6. ***Reliability –*** As it relates to the predicted number of cracked slabs at the end of the design life.

Because an intersection carries traffic from two or more roadways, the concrete slab thickness may need to be greater than the thickness on the approaching roadways. For both roundabouts and traditional intersection pavements, typical concrete thicknesses can range from 5 to 10 inches (125 to 250 mm). The exact required thickness will depend on expected traffic, local conditions, past history, and other factors. See Table 1 on the next page for more detail.

Table 1. Typical Concrete Pavement Designs based on Street Classification *

Street Class	2-way ADTT **	Typical Thickness	Dowels† Needed?
Light Residential	2-4	4 - 5 in. (100-125 mm)	No
Residential	10-50	5 - 7 in. (125-175 mm)	No
Collector	50-500	5.5 - 9 in. (135-225 mm)	If ADTT > 100
Business	400-700	6 - 9 in. (150-225 mm)	Yes
Industrial	300-800	7 - 10.5 in. (175-260 mm)	Yes
Minor Arterial	300-600	6 - 9 in. (150-225 mm)	Yes
Major Arterial	700-1500	7 - 11 in. (175-275 mm)	Yes

* Note: These are not necessarily recommended design thicknesses. Rather, a detailed analysis should be completed to determine the required pavement structure.
** ADTT = Average Daily Truck Traffic.
† Dowels always placed perpendicular to joint.
Reference: ACPA publication IS184P, Design of Concrete Pavement for City Streets

The process of determining the jointing pattern for a concrete roundabout can seem confusing. However, following a few simple rules and a step-by-step method will assist designers and produce an effective pavement jointing layout that can be easily constructed.

First, the general process involves choosing the joint layout philosophy. For roundabouts, the designer can choose to either joint the circle separately from the approaching roadways, or design a portion of the circle as a "pave-through." Figures 1 and 2 show these options graphically.

Once the philosophy has been chosen, keep in mind these rules when designing the joint layout:

Things to Do
- Match existing joints / cracks wherever possible
- Place joints to meet in-pavement structures
- Remember maximum joint spacing:
  - 24 times concrete thickness (on unstabilized base)
  - 21 times concrete thickness (on stabilized base)
  - max. of 15 ft. (4.6 m) for streets & highways

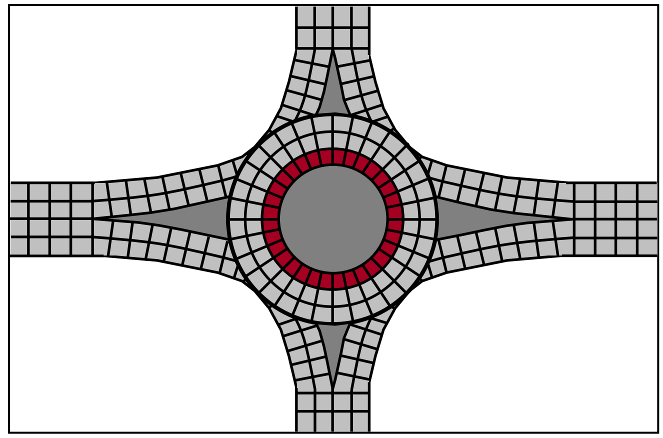


Figure 1. Joint Layout for Roundabout, Isolating Circle from Legs

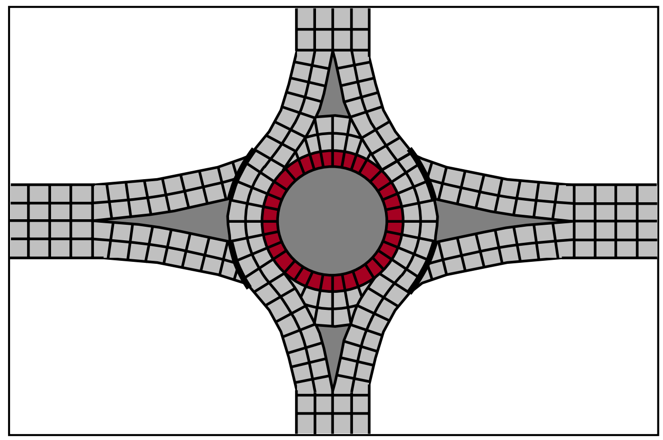
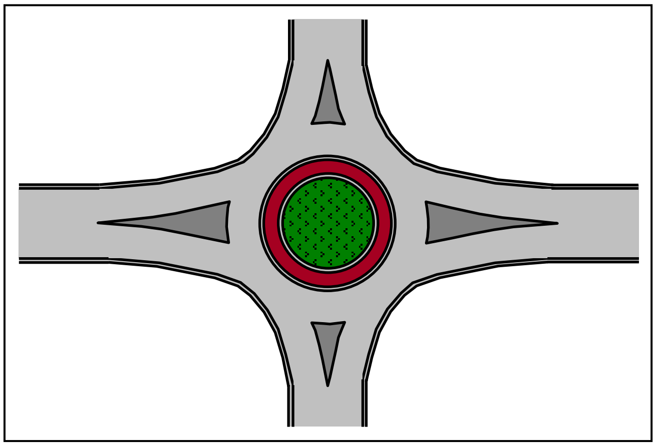


Figure 2. Joint Layout for Roundabout, "Pave-Through" Option

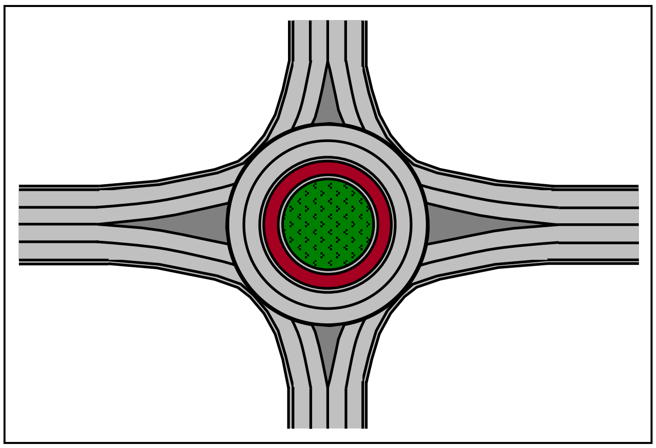
- Understand adjustments can be made to joint locations!
- Be Practical

Things to Avoid
- Slabs less than 1 ft (0.3 m) wide
- Slabs greater than 15 ft (5.0 m) wide
- Angles less than 60° (~90° is best) – do this by dog-legging joints through curve radius points
- Creating interior corners (L-shaped slabs)
- Odd Shapes (keep slabs square or pie-shaped)

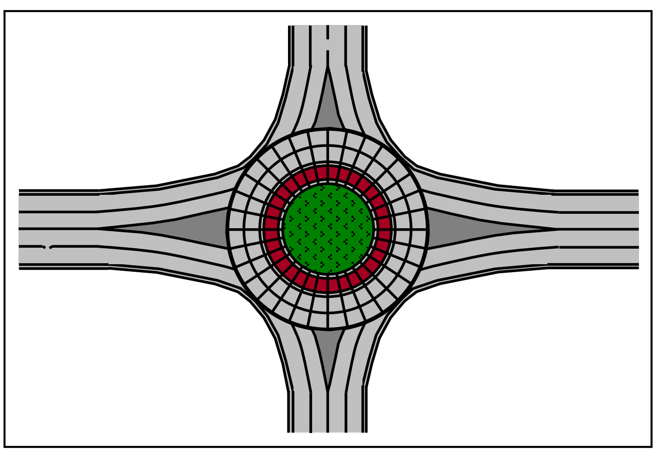
Developing a workable jointing plan is vital to making sure the joint layout will be constructed properly; the plan is the key by which the joints will be correctly located. At least one agency has opted to require the contractor to submit the jointing plan, prepared according to ACPA recommendations. For roundabouts, these recommendations include the following six steps:



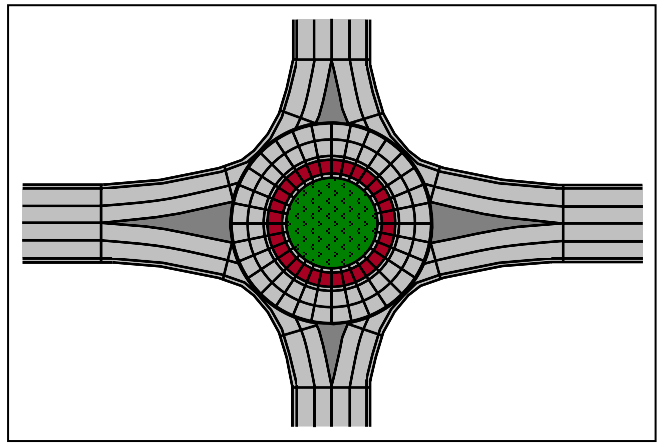
Step 1. Draw all pavement edge and back-of-curb lines in the plan view. Draw locations of all manholes, drainage inlets, and valve covers so that joints can intersect these.



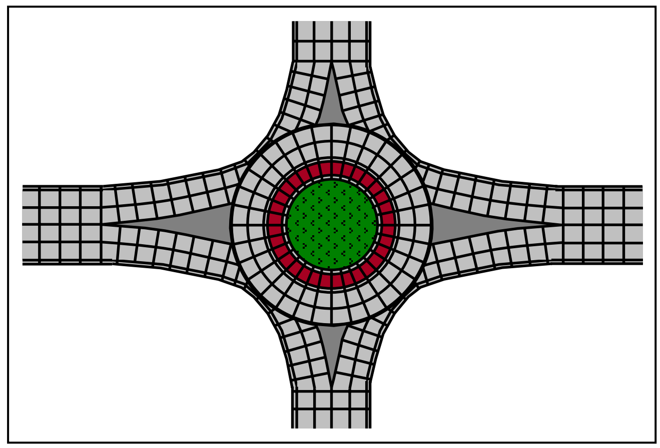
Step 2. Draw all lane lines on the legs and in the circular portion. If isolating circle from legs, do not extend these through the circle. If using “pave-through” method, determine which roadway will be paved through. Make sure no distance is greater than the maximum recommended width.



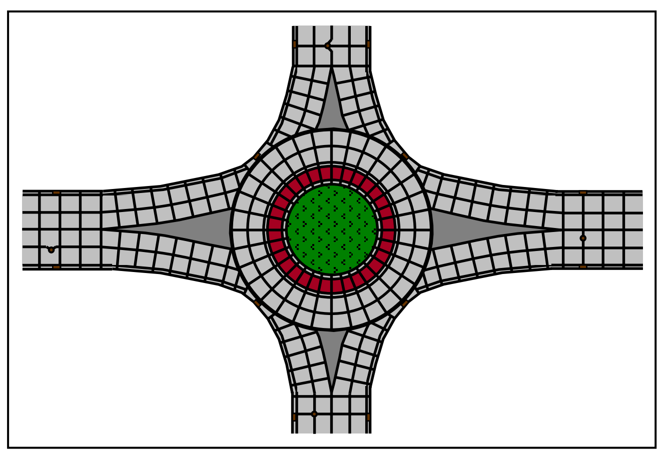
Step 3. In the circle, add “transverse” joints radiating out from the center of the circle. Make sure that the largest dimension of a pie-shaped slab is smaller than the maximum recommended. Extend these joints through the back of the curb & gutter.



Step 4. On the legs, add transverse joints at all locations where a width change occurs in the pavement (at bullnose of median islands, begin & end of curves, tapers, tangents, curb returns, etc.). Extend these joints through the back of the curb & gutter.



Step 5. Add transverse joints beyond & between those added in Step 4. Space joints out evenly between other joints, making sure to not violate maximum joint spacing.



Step 6. Make adjustments for in-pavement objects, fixtures, and to eliminate L-shapes, small triangular slabs, etc.

Case Study

An award-winning roundabout was constructed at 110th Street & Lamar Avenue in Overland Park, Kansas in 2002. The roundabout was chosen by City of Overland Park traffic engineers instead of a signalized intersection due to other signalized intersections nearby and the projected increase in traffic in the area surrounding the new Overland Park Convention Center.

The project was designed and bid with two alternatives, one asphalt and one concrete. The City ended up choosing the 9.5-inch concrete alternative after considering life-cycle cost, maintenance, and the rigidity of concrete, given the fact that the circular motion of vehicles on the roundabout would rapidly deteriorate asphalt pavement.

The roundabout is designed for a total average daily traffic (ADT) of 26,000 vehicles per day, 10,000 from 110th Street and 16,000 from Lamar Avenue. The outside diameter of the roundabout is about 200 feet, and the inside diameter is about 130 feet. The circular roadway of the roundabout has two travel lanes, but the designers chose three paving lanes to prevent unwanted longitudinal cracks. Vehicles follow the pavement markings instead of joint lines, even during inclement weather.

Joint layout details required careful attention, and the project team decided to isolate the circular portion of the concrete roundabout from all four approach legs to the intersection. This ensured a reduced potential for sympathy cracks between approach legs and the roundabout itself. The inner ring was constructed first, and the placement proceeded outward until the approach legs were completed. The 110th-Lamar roundabout was completed with a full closure and detour, but in many cases, traffic can be maintained through the work zone during construction by constructing half the roundabout at a time.

Figure 3. Example of widened gutter to eliminate small triangular-shaped areas.

Figure 4. Inner ring complete, second ring under construction. Note the dowel baskets laid out in the circular portion, for the second and third rings.

Figure 5. Completed concrete roundabout.

ACPA

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