Concrete Pavement Roundabouts

Idaho's Local Transportation Conference
Boise, Idaho

IOWA STATE UNIVERSITY
Institute for Transportation

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National Concrete Pavement Technology Center

CP Tech Center

National Ready Mixed Concrete Association

- National Trade Association – Established in 1930
- HQ in Alexandria, VA
- 1,400+ Member Companies
- NRMCA Represents ~75% of North American Ready Mixed Production
- Mission - Serve Industry and Partners Through:
  - Compliance and Operations
  - Engineering
  - Government Affairs
  - *Local Paving: Pave Ahead™ Initiative (PaveAhead.com)*
  - *Structures and Sustainability: Build With Strength™ Initiative*

NRMCA

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DURABLE. SUSTAINABLE. CONCRETE.

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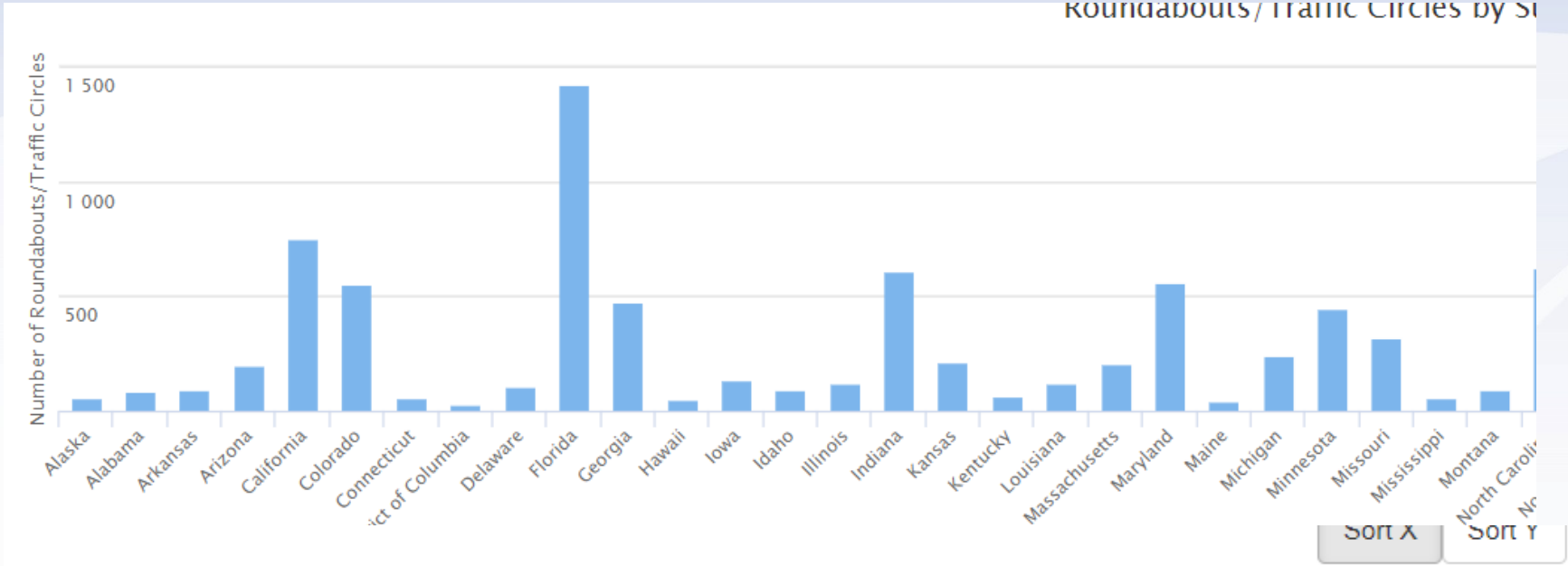
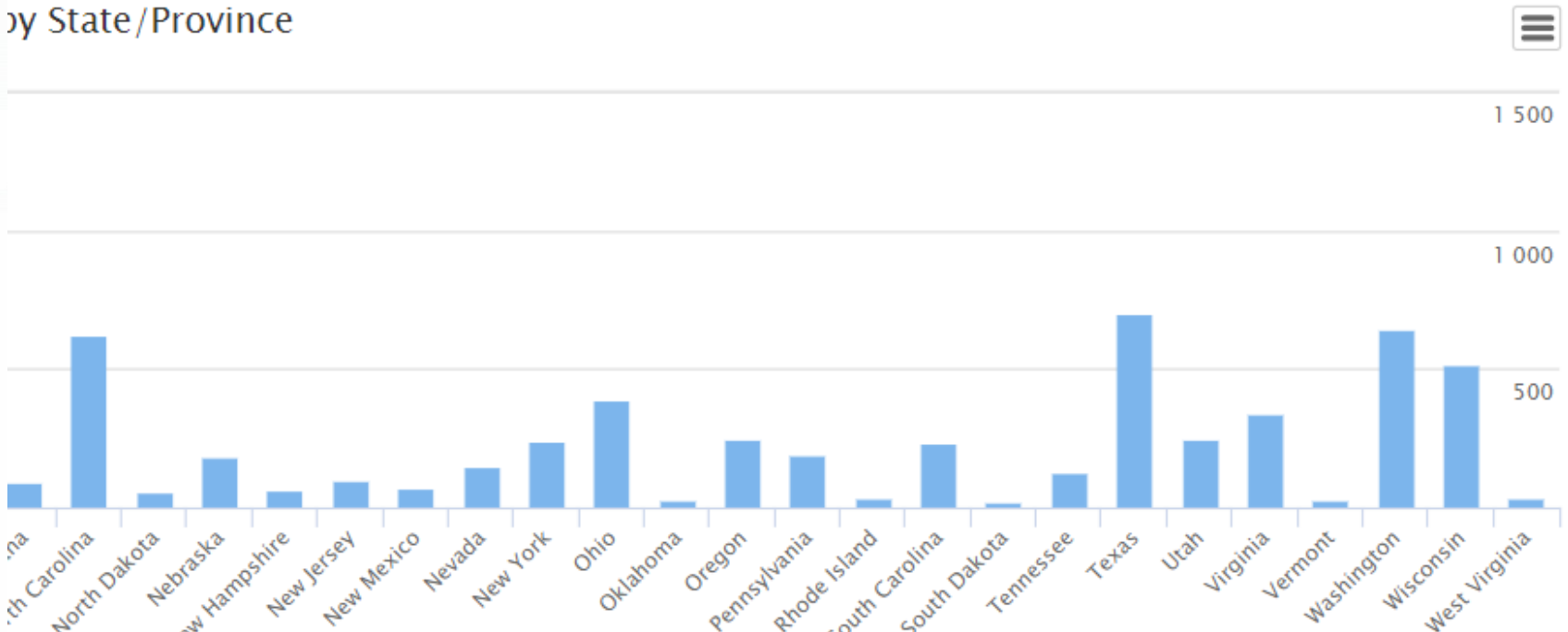
Concrete Pavement Versatility

Why Roundabouts Anyway?

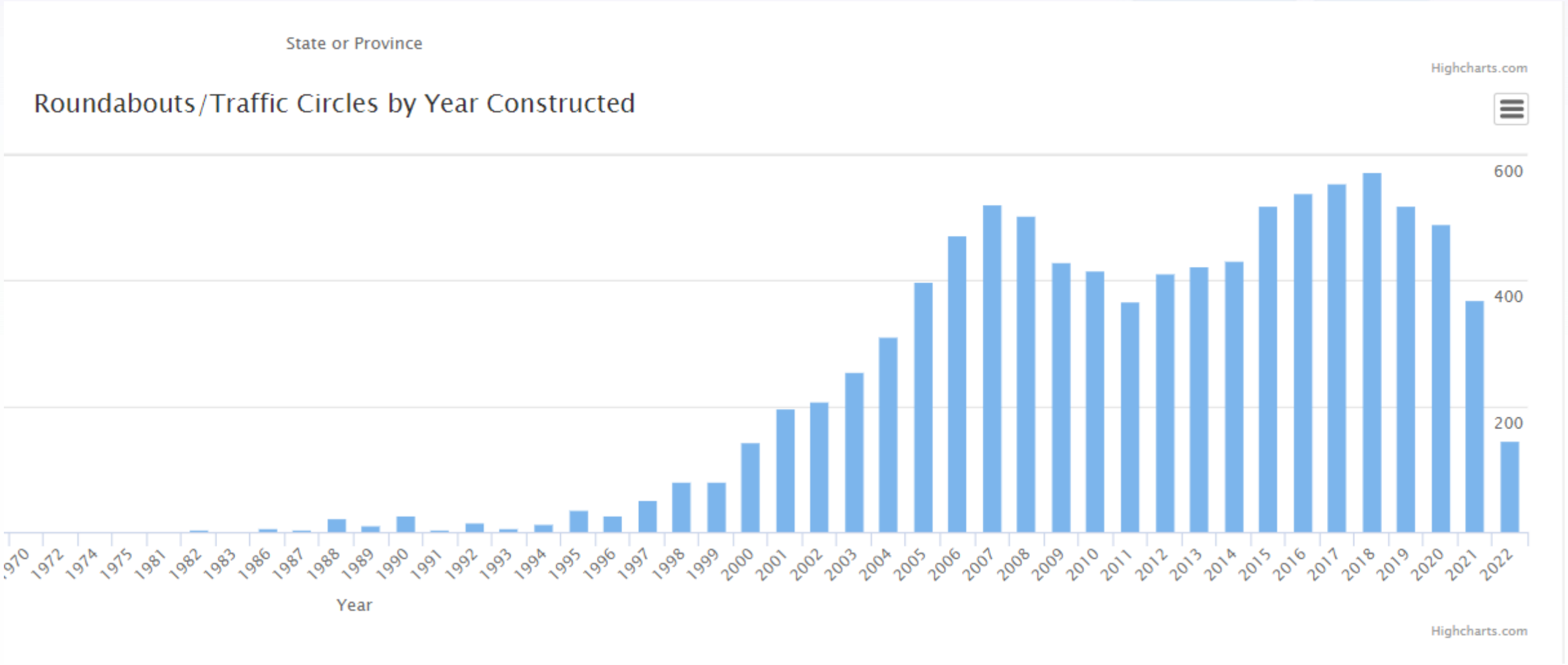
- According to FHWA:
  - Up to 90% reduction in fatalities
  - 76% reduction in injury crashes
  - 30-40% reduction in pedestrian crashes
  - 75% fewer conflict points than 4-way intersections
  - 30-50% increase in traffic capacity
  - No signal equipment to install/maintain
  - No left-turn lane and reduced need for storage lanes

Roundabouts.kittelson.com





Roundabouts in the US by Year Constructed



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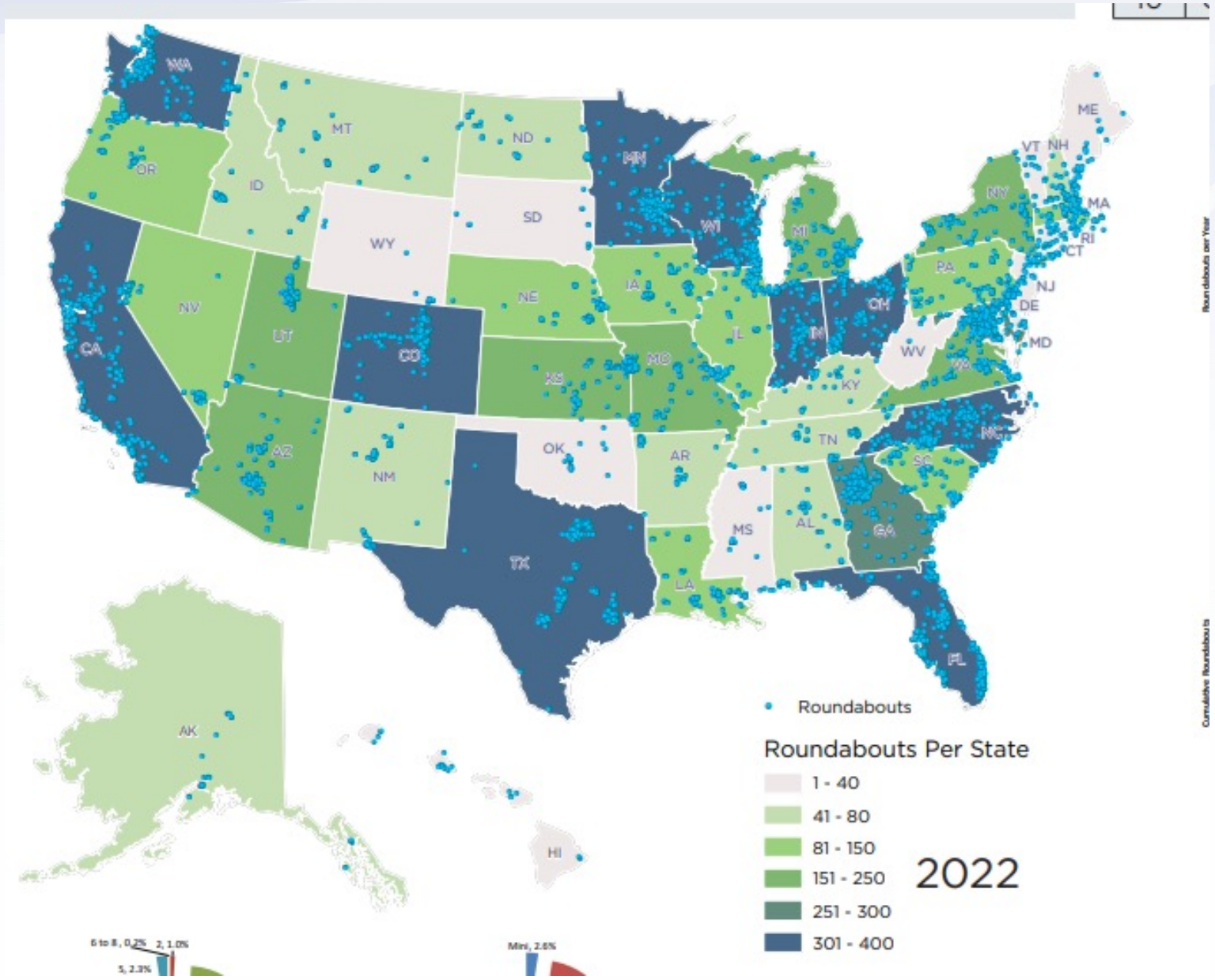


Where are Concrete Pavements Historically Used?

Answers:

- High traffic areas
- Areas with lots of turning movements
- Situations where we need a “long-term fix”
- Situations where future maintenance must be kept to an absolute minimum
- Areas where future disruption to traffic must be kept to a minimum
- Economical over long-term – Life-Cycle Cost (LCC)
- Areas where safety is a priority – surface characteristics


© 2002 Steve Muench

Things to Consider for all Intersections and Roundabouts

- Thickness
- Jointing
  - Spacing
  - Type
  - Layout
- Constructability and MOT
- Other:
  - Drainage
  - Reconstruction versus inlay
  - Subgrade and subbase requirements

Thickness Design for Intersections and Roundabouts

Pavement Thickness Design

- AASHTO
  - 1993 Pavement Design Guide
  - Pavement ME Design (MEPDG)
    - Implemented in many states
    - Under calibration in many other states
- Concrete Pavement Industry Method
  - PavementDesigner.org
    - Developed for Street & Local Road Design

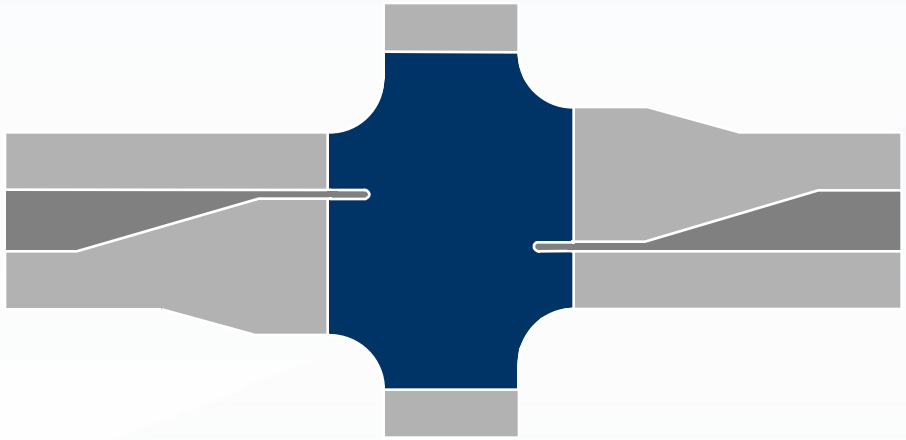
- **REGARDLESS OF METHOD MUST CONSIDER CUMULATIVE TRAFFIC!!**

Thickness Impacts Jointing!

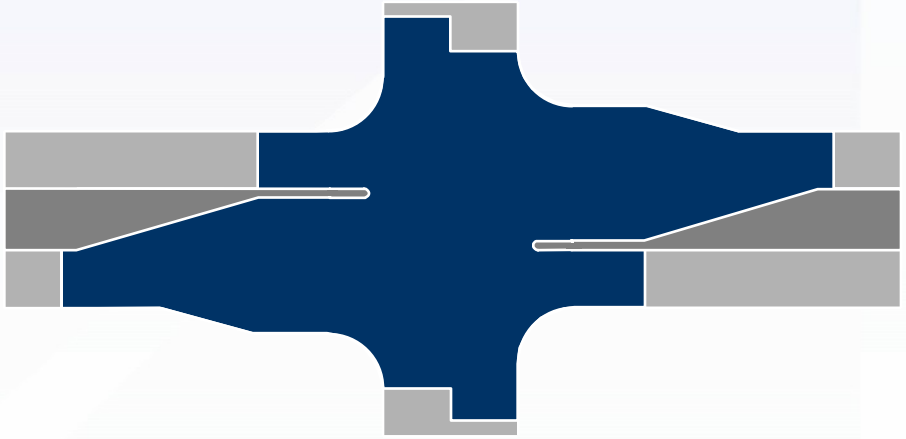
Design may be based on AASHTO, PavementDesigner, etc.

Class	ADT	ADTT	Thickness
Light residential	< 200	2-4	4.0-5.0 in.
Residential	200-1,000	10-50	5.0-6.0 in.
Collector	1,000-8,000	50-500	5.5-8.0 in.
Business	11,000-17,000	400-700	6.0-8.0 in.
Industrial	2,000-4,000	300-800	6.5-9.5 in.
Arterial (minor)	4,000-15,000	300-600	6.5-9.5 in.
Arterial (major)	4,000-30,000	700-1,500	7.0-10.0 in.

Concrete Intersections and Roundabouts: Thickness



Physical Area



Functional Area

Concrete Intersections and Roundabouts: Thickness

Physical Area Functional Area

Roadway 1	Roadway 2	Physical Area Thickness
Low ADTT (T1)	Low ADTT (T2)	T2
Low ADTT (T1)	High ADTT (T3)	T3
High ADTT (T3)	High ADTT (T3)	T3 + 0.5 to 1 in.

T3>T2>T1

Basic Principles for Jointing and Joint Layout

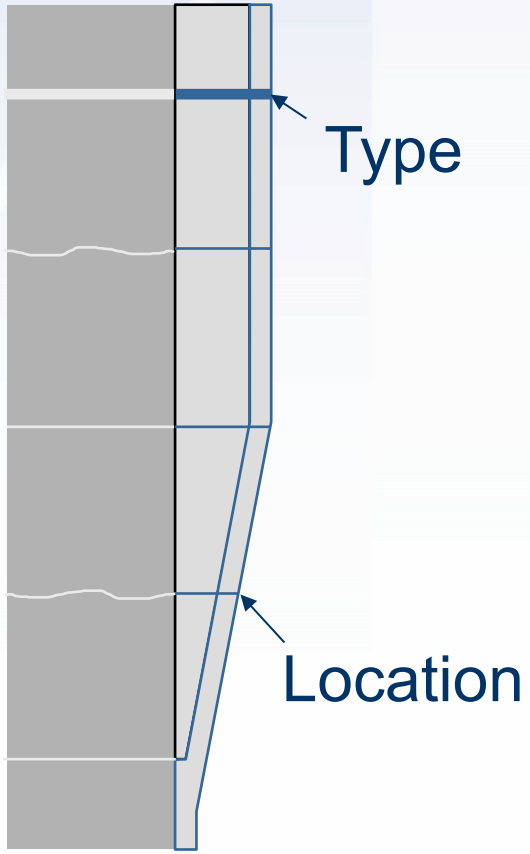
Joint Spacing “Best Practices” Summary

- Keep it Short!
- Keep it Uniform!
- Keep it Perpendicular!
- Keep it Simple!
- Keep it Practical!

Rules for Joint Layout

Things to Do

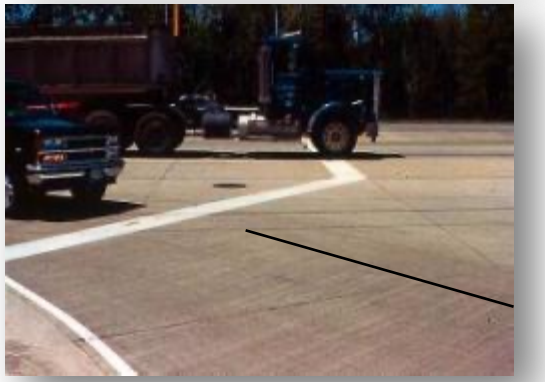
- Match existing joints or cracks – location AND type!
- Cut joints at the proper time and to the proper depth
- Place joints to meet in-pavement structures
- Remember maximum joint spacing
- Place isolation joints where needed
- **Understand that joint locations can be adjusted in the field!**
- Be Practical



Rules for Joint Layout

Things to Avoid:

- Slabs < 2 ft wide
- Slabs > 15 ft wide
- Angles < 60º (90º is best)
  - Use “dog-leg” joints through curve radius points
- Creating interior corners
- “Odd” shapes
  - Keep slabs nearly square or rectangular, when possible



Recommended Maximum Joint Spacing

$$ML = T \times C_s$$

ML = Maximum length between joints (in.)

T = Slab thickness (in.)

C_s = Support constant

- Use 24 for subgrades or unstabilized [granular] subbases;
- Use 21 for stabilized subbases (ATB, CTB, lean concrete) or existing concrete or asphalt pavement;
- Use 12 to 15 for thin bonded overlays on asphalt

Joint Spacing Recommendations

For Streets, Roads, and Highways:

- Use ML = T x C_s
- Keep ratio of transverse to longitudinal spacing at less than 1.5
- Keep maximum spacing of transverse joints to 15 ft for plain concrete unless local history shows longer panels work

What About Load Transfer?

- Aggregate Interlock
  - Maximum aggregate size is important
- Mechanical connection
  - Dowel bars
  - Tiebars
- Subbase support

Dowel Bar Recommendations

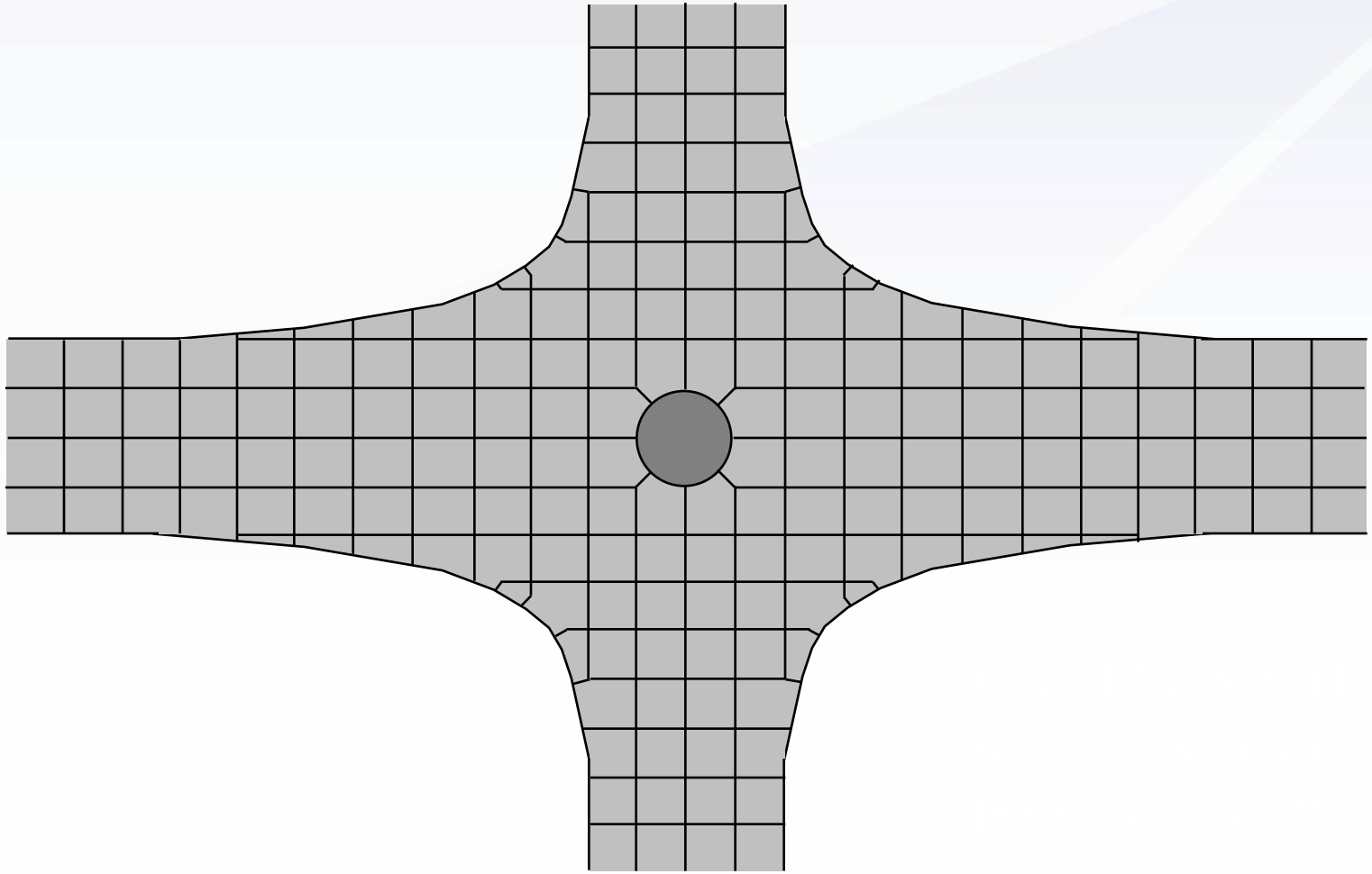
Pavement Thickness	Dowel Diameter
Less than 7.0 in.	None
7.0 – 7.9 in.	1 in.
8.0 – 9.9 in.	1-1/4 in.
Greater than 10.0 in.	1-1/2 in.

ACPA

Education | Training | Technology Transfer

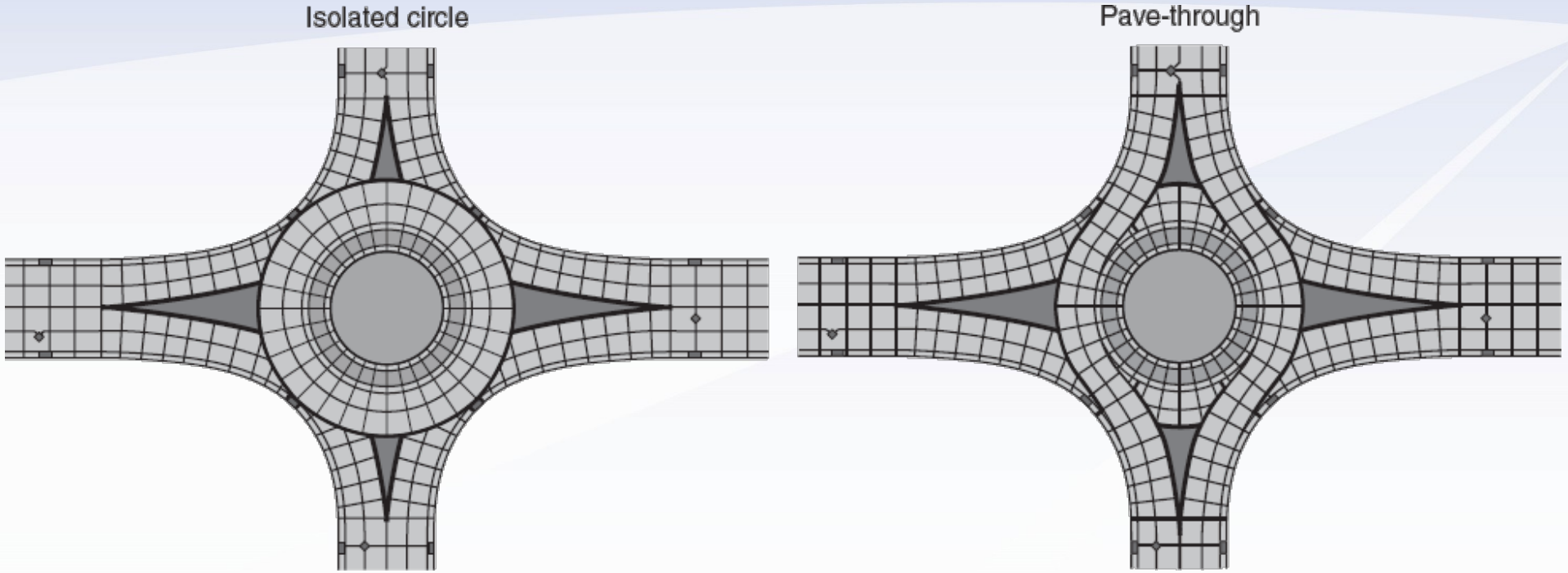
Joint Layout for Roundabouts

Layout Joints as Normal Intersection



Jointing

- Decide on joint layout philosophy
  - ~~Like normal intersection~~
  - Isolate circle from legs
  - Pave-through, isolate two legs
  - Other philosophy, based on experience
- Follow 6-step method
- Joints in circular portion radiate from center
- Joints in legs are normal (perpendicular)



Concrete Roundabout Design And Construction

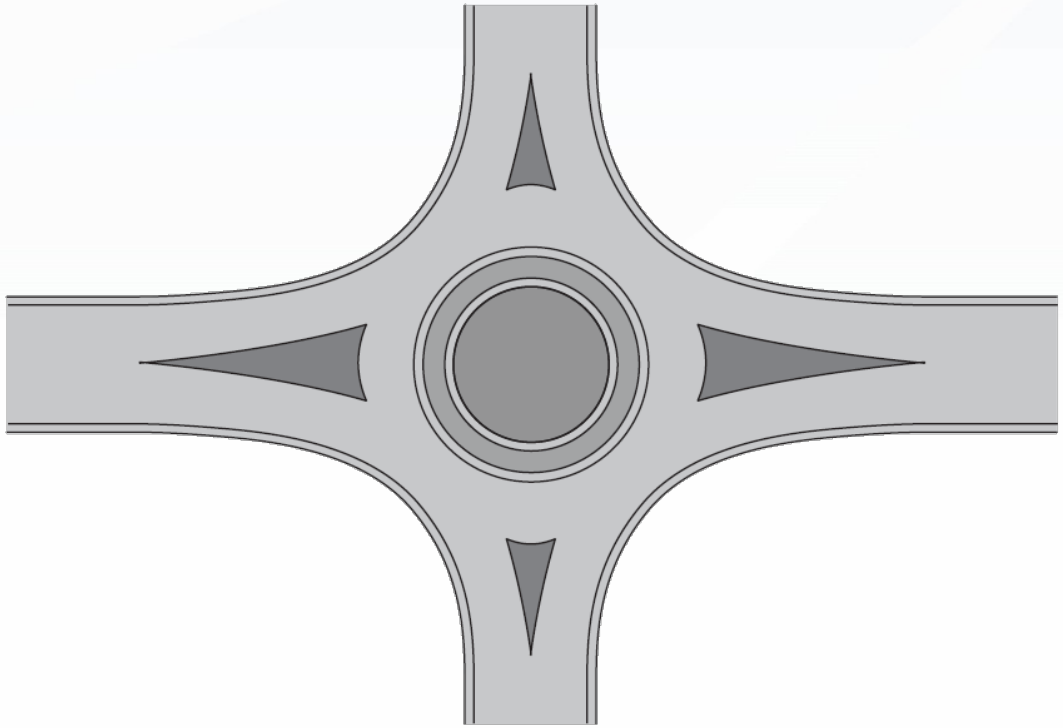
6-STEP METHOD FOR JOINTING ROUNDABOUTS

http://wikipave.org/index.php?title=Joint_Layout

Jointing a Roundabout

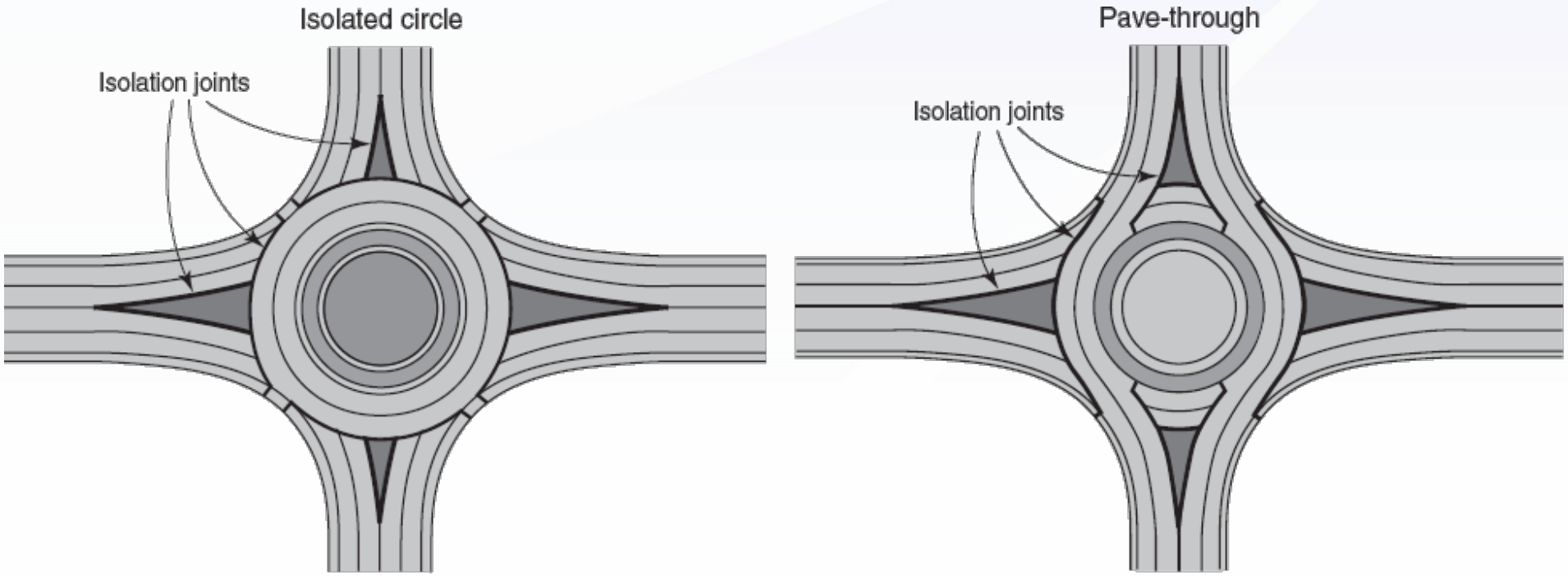
Step 1: Draw all pavement edges and back-of-curb lines in plan view.

Also, draw locations of manholes, drainage inlets, and valve covers



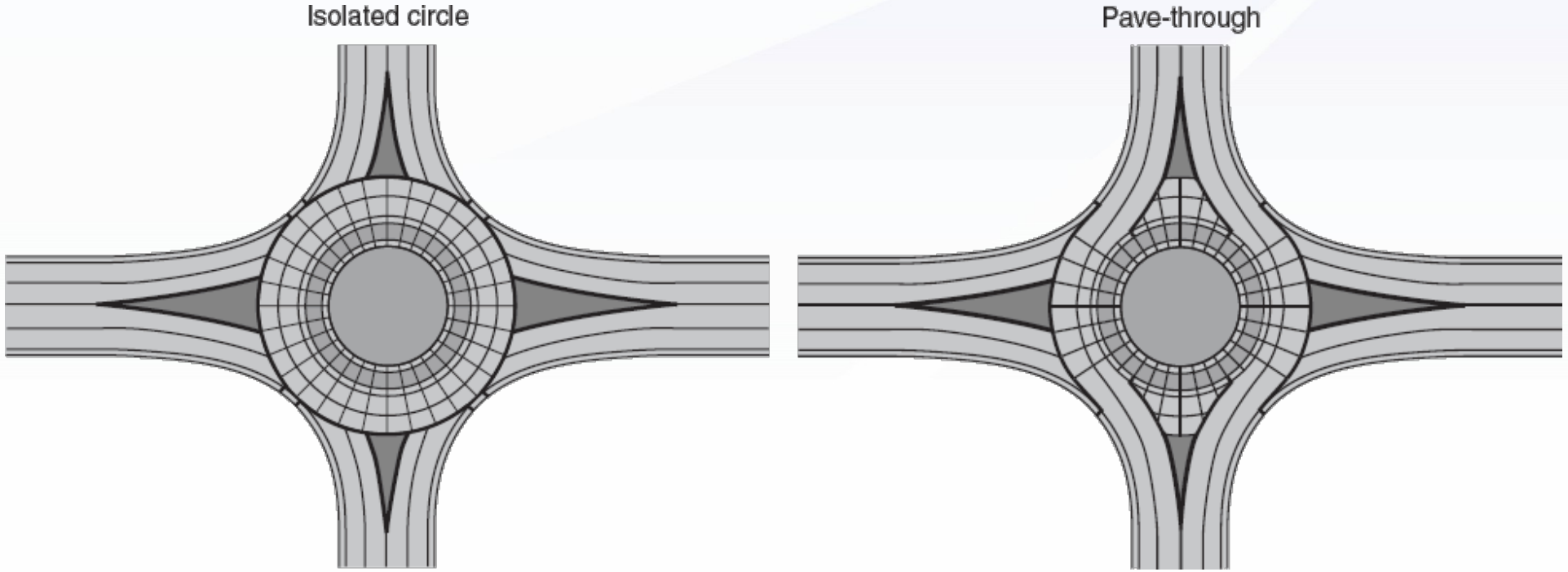
Jointing a Roundabout

Step 2: Draw all lane lines on the legs and in the circular portion, accounting for roundabout type.



Jointing a Roundabout

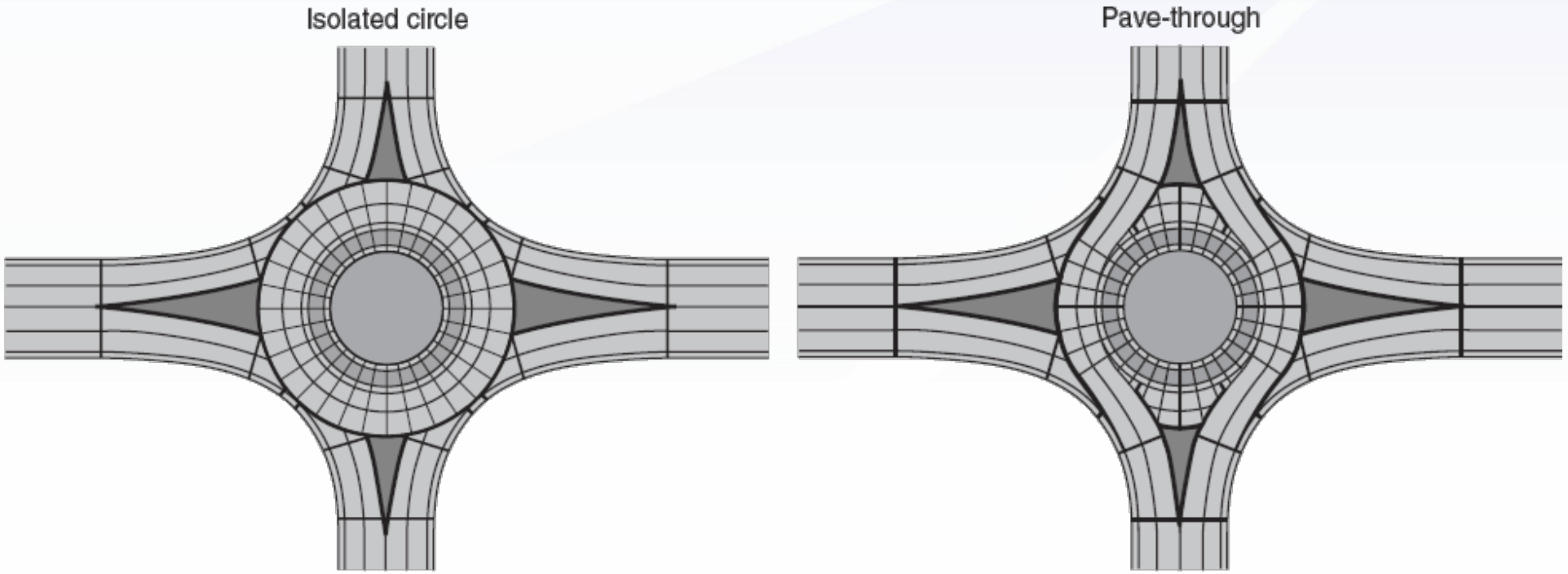
Step 3: Add “transverse” joints in the circle, being mindful of the maximum joint spacing. Extend joints through the curb/ gutter.



Example – Isolated Truck Apron

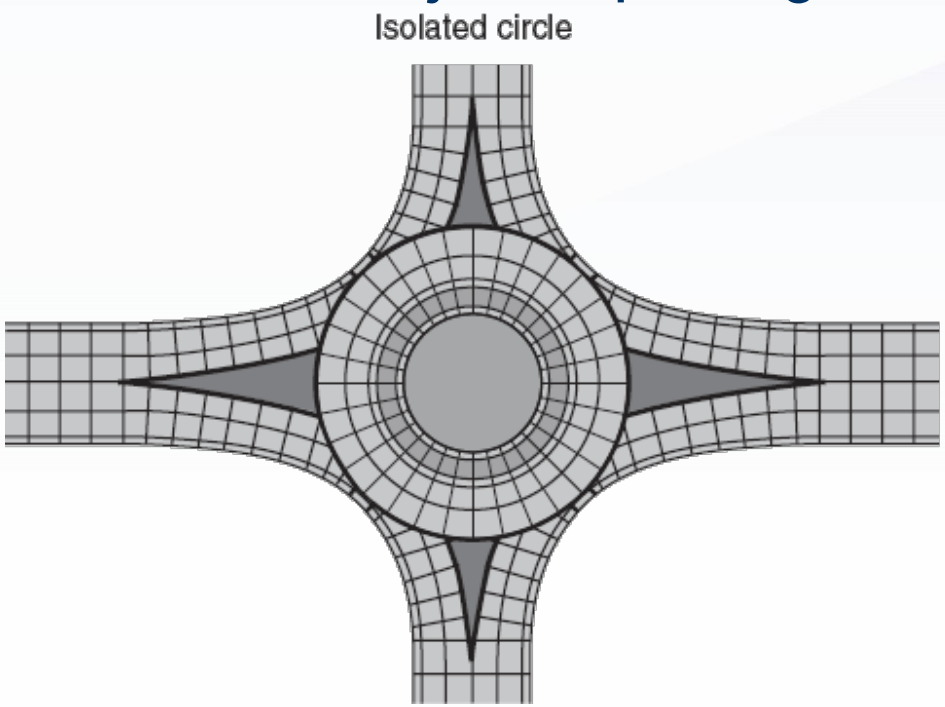
Jointing a Roundabout

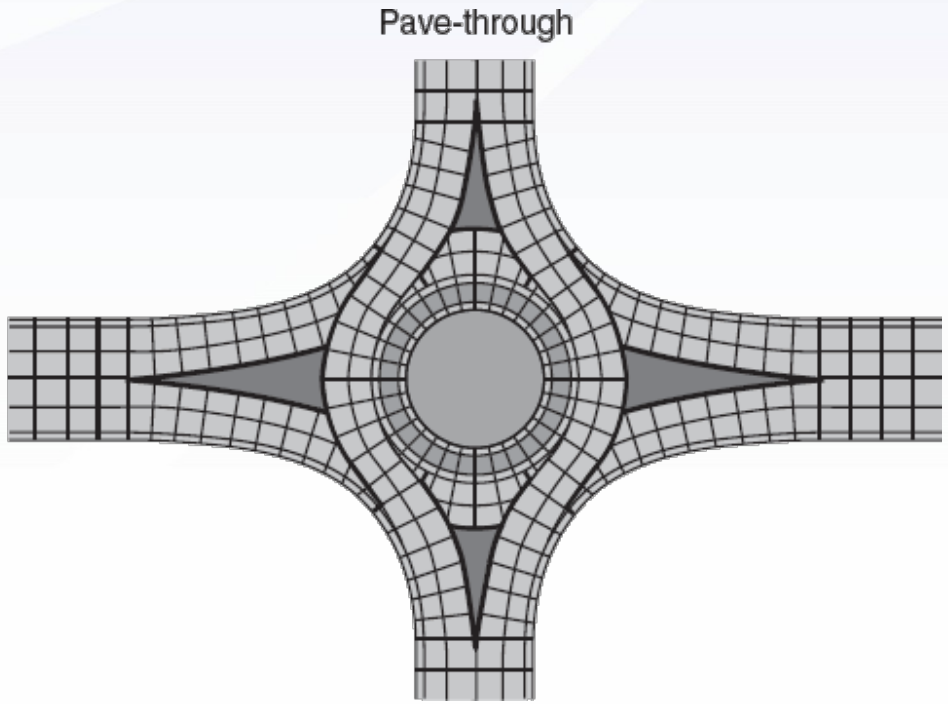
Step 4: On the legs, add transverse joints where width changes occur.



Jointing a Roundabout

Step 5: Add transverse joints between those added in Step 4, minding the maximum joint spacing.

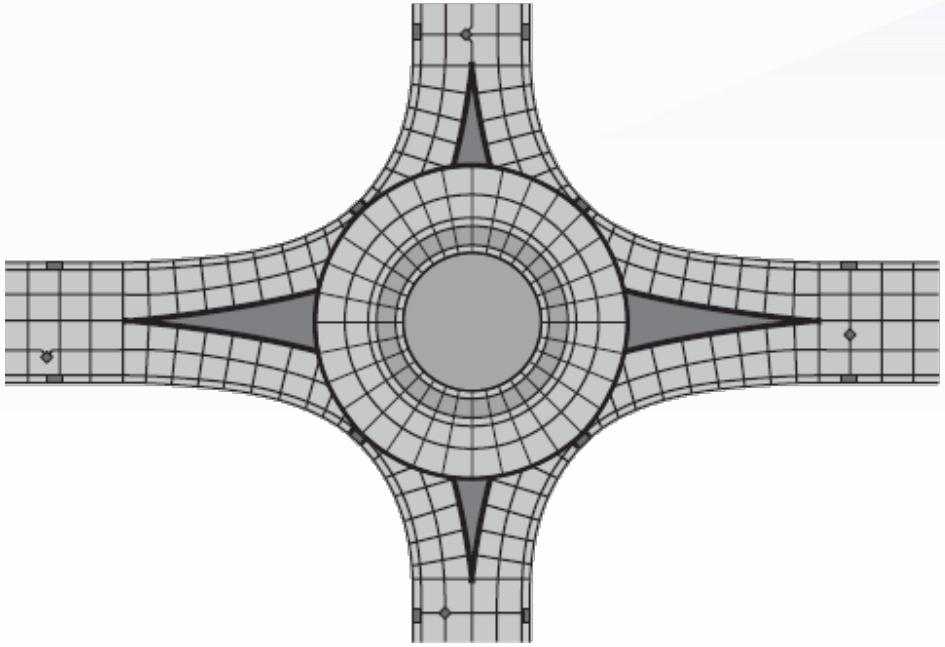




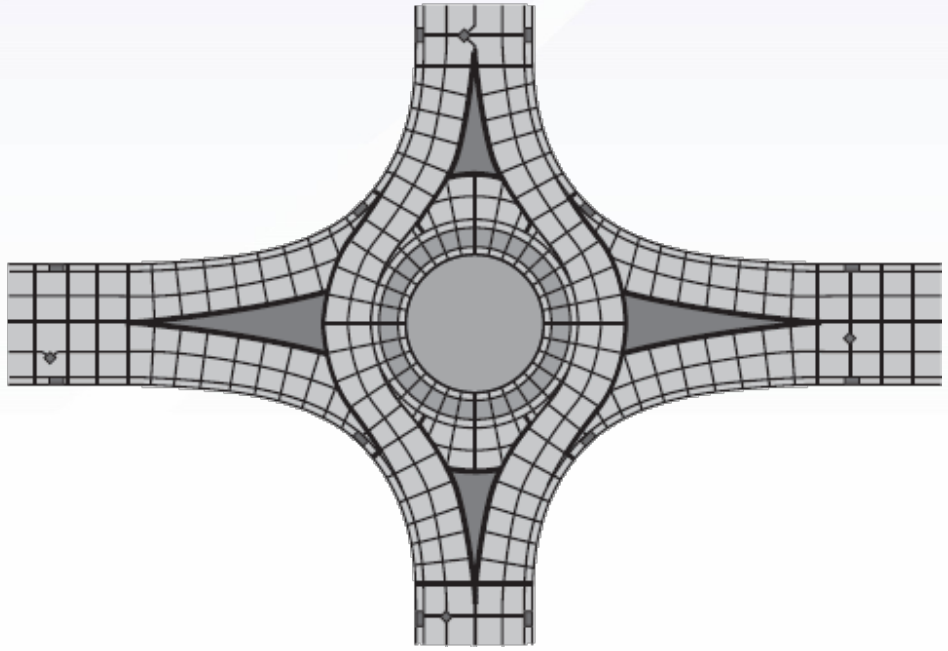
Jointing a Roundabout

Step 6: Make adjustments for in-pavement objects, fixtures, and to eliminate odd shaped slabs.

Isolated circle

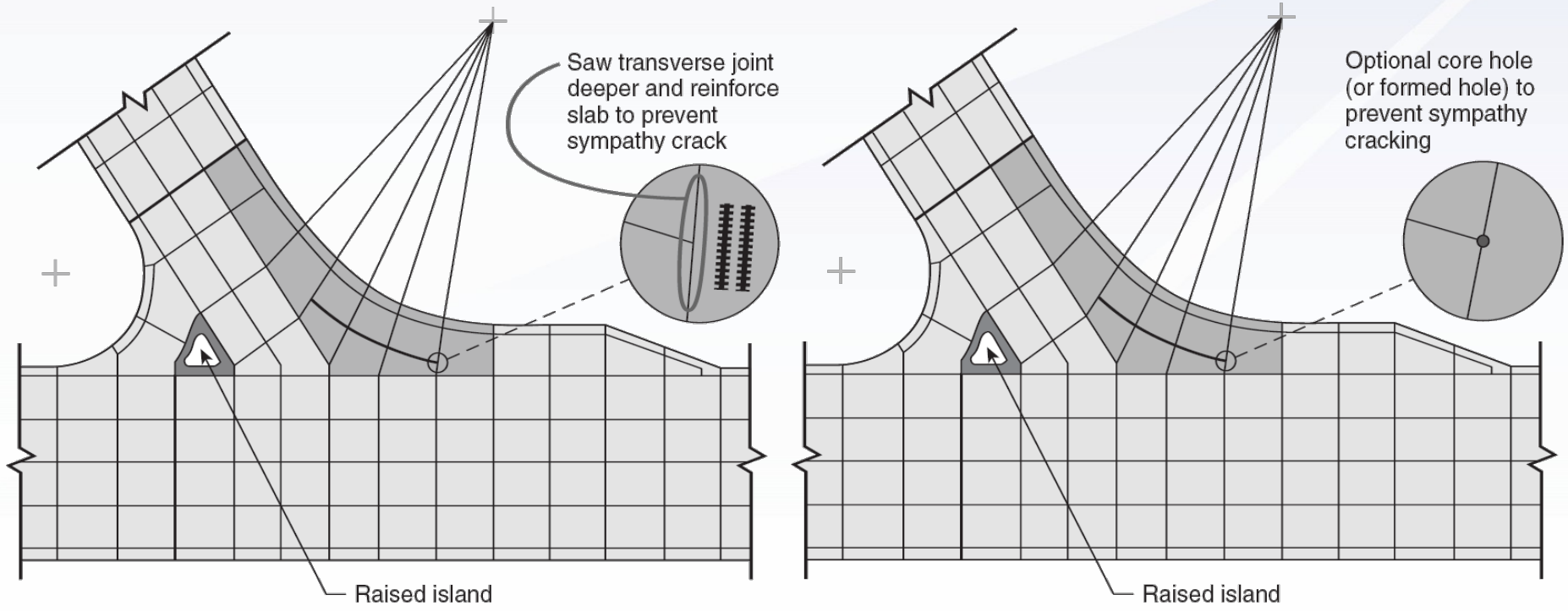


Pave-through



Properly Jointed Roundabout

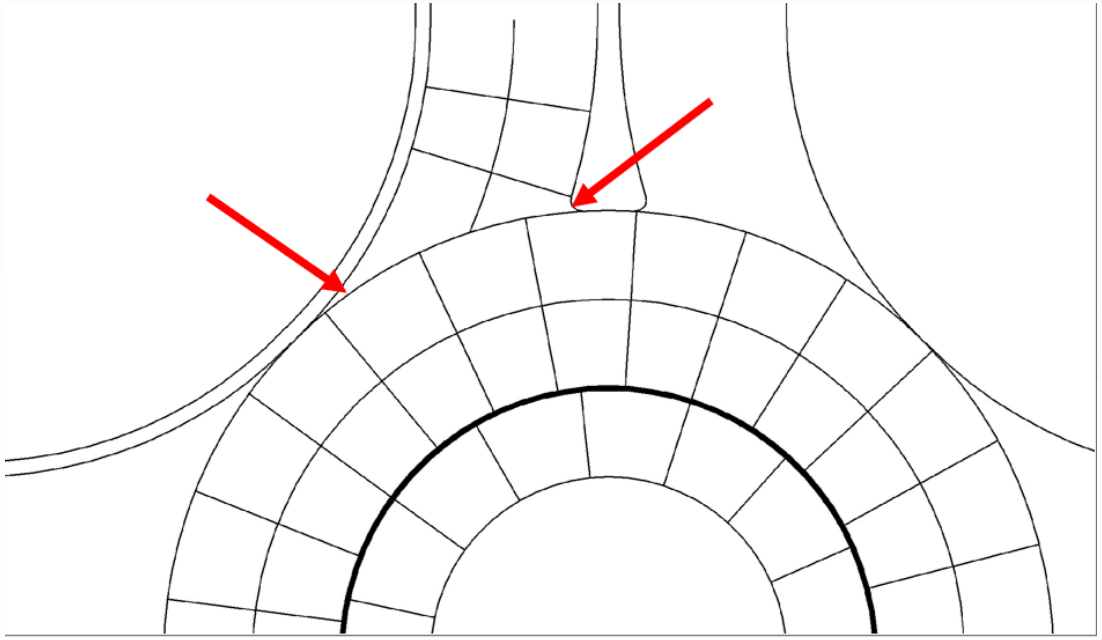
What If I Have to dead-end a Joint?

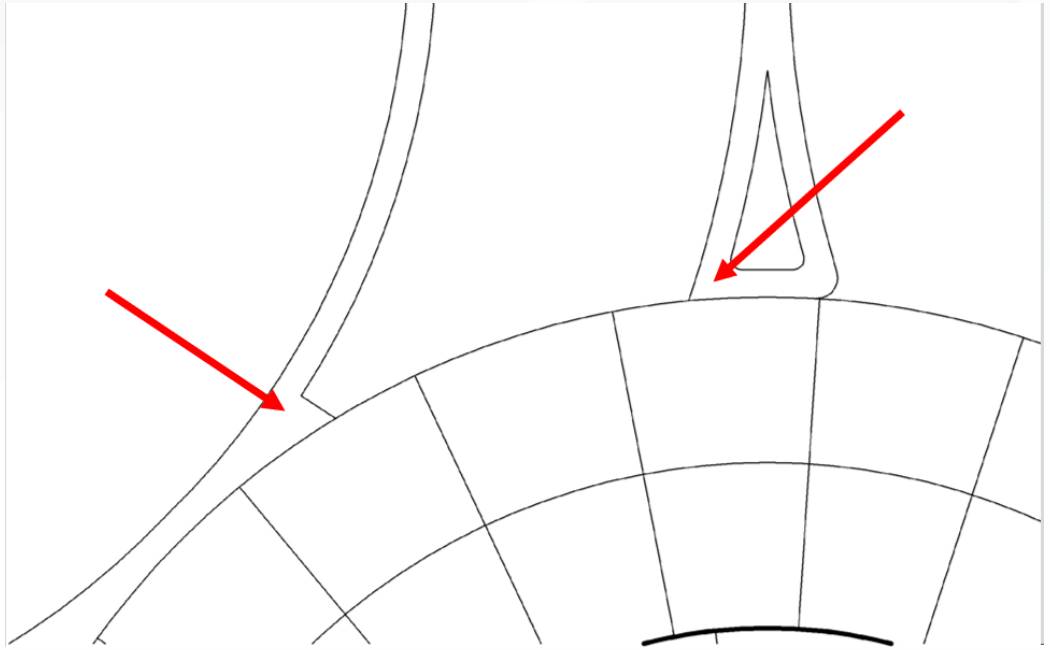


What If I Have to Dead-end a Joint?

What If I Have to Dead-end a Joint?

What About Narrow Slivers





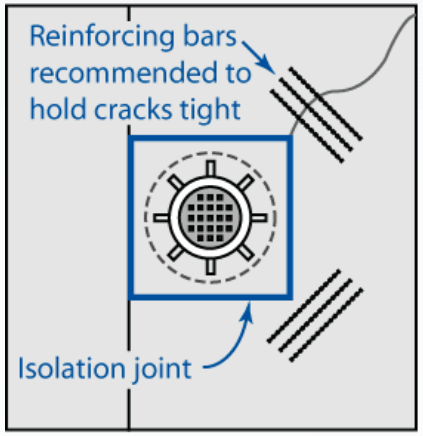
Credit: Jim Powell, NWCPA

What If I Have an Odd Shaped Slab?

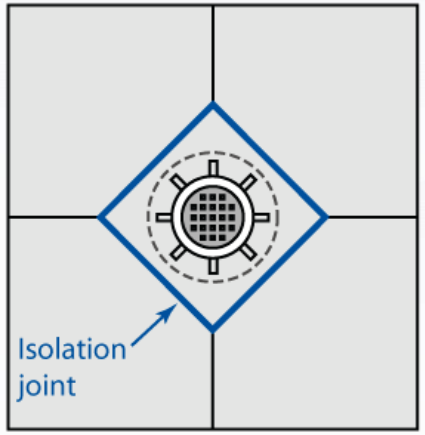
Concrete Intersections: Jointing

Box Out Fixture Details

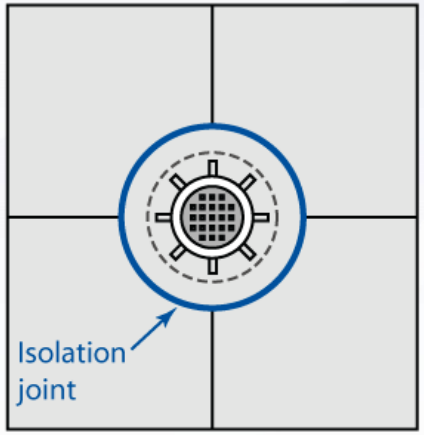
Square Manhole Boxout



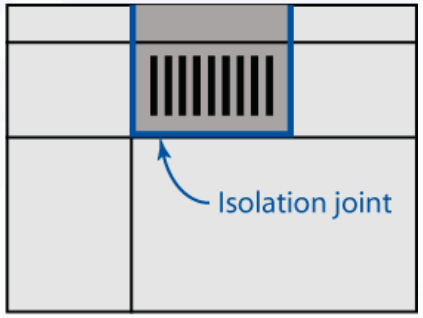
Diagonal Manhole Boxout



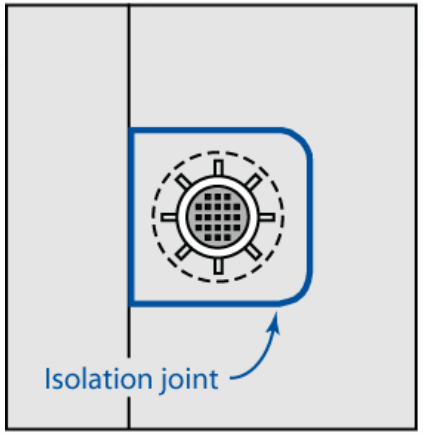
Circular Manhole Boxout



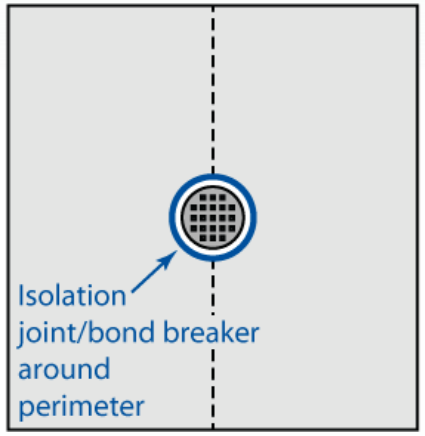
Square Inlet (no boxout)



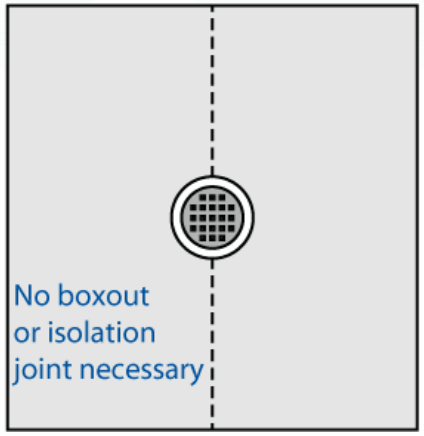
Square Boxout with Fillets



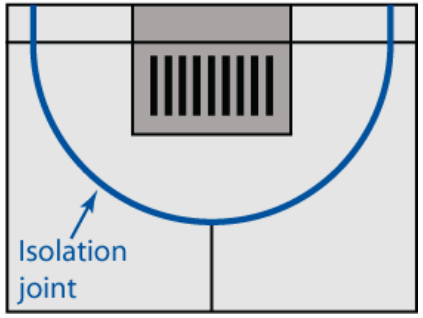
Manhole (No Boxout)



Telescoping Manhole



Round Inlet Boxout




59 WEST

If You DO Box Out Properly...Good Results Happen!

If You DON'T Box Out Properly...Bad Things Happen!

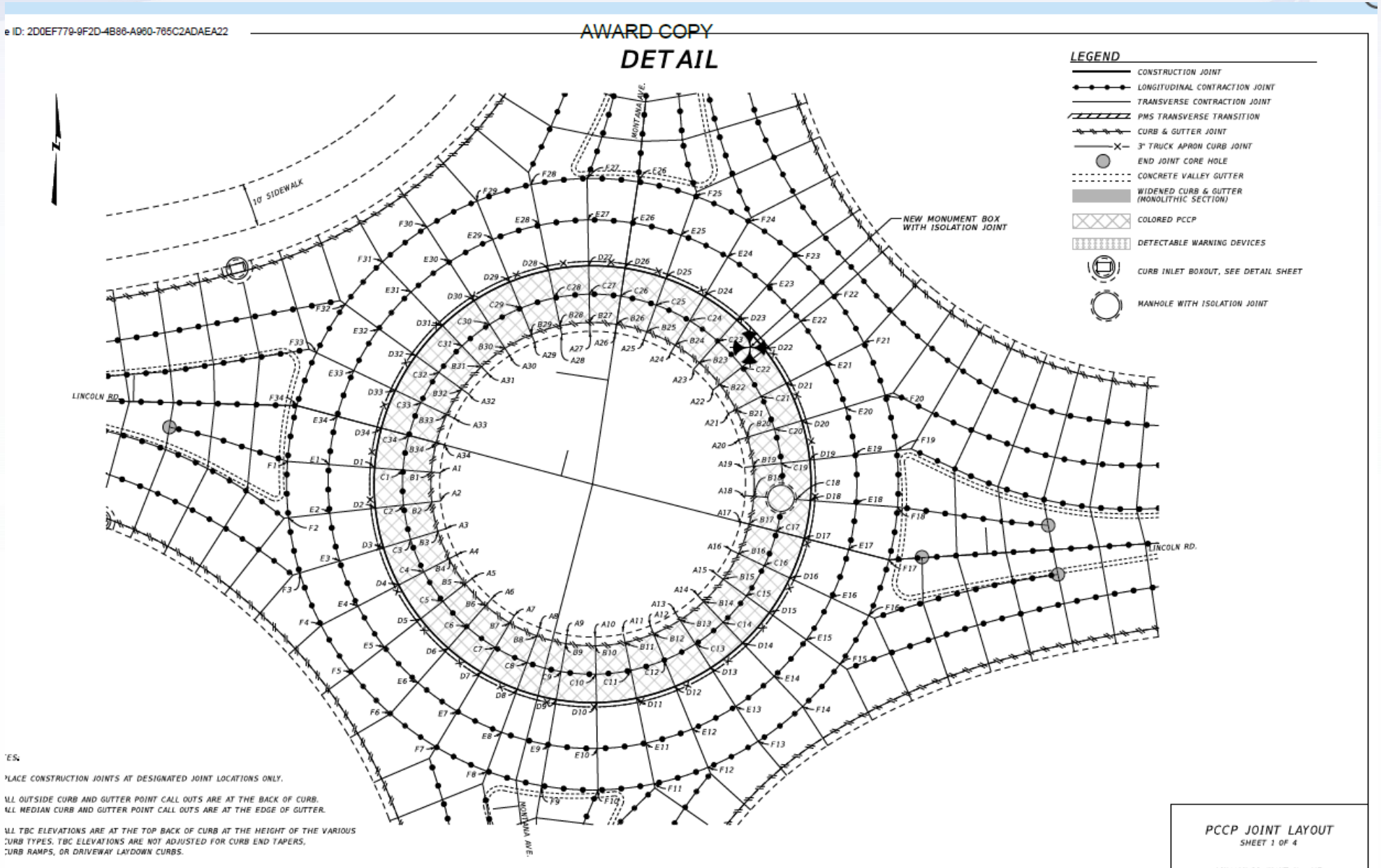
Where There's a Will, There's a Way…

Old…BUT NO CRACKS!

Good Practice...

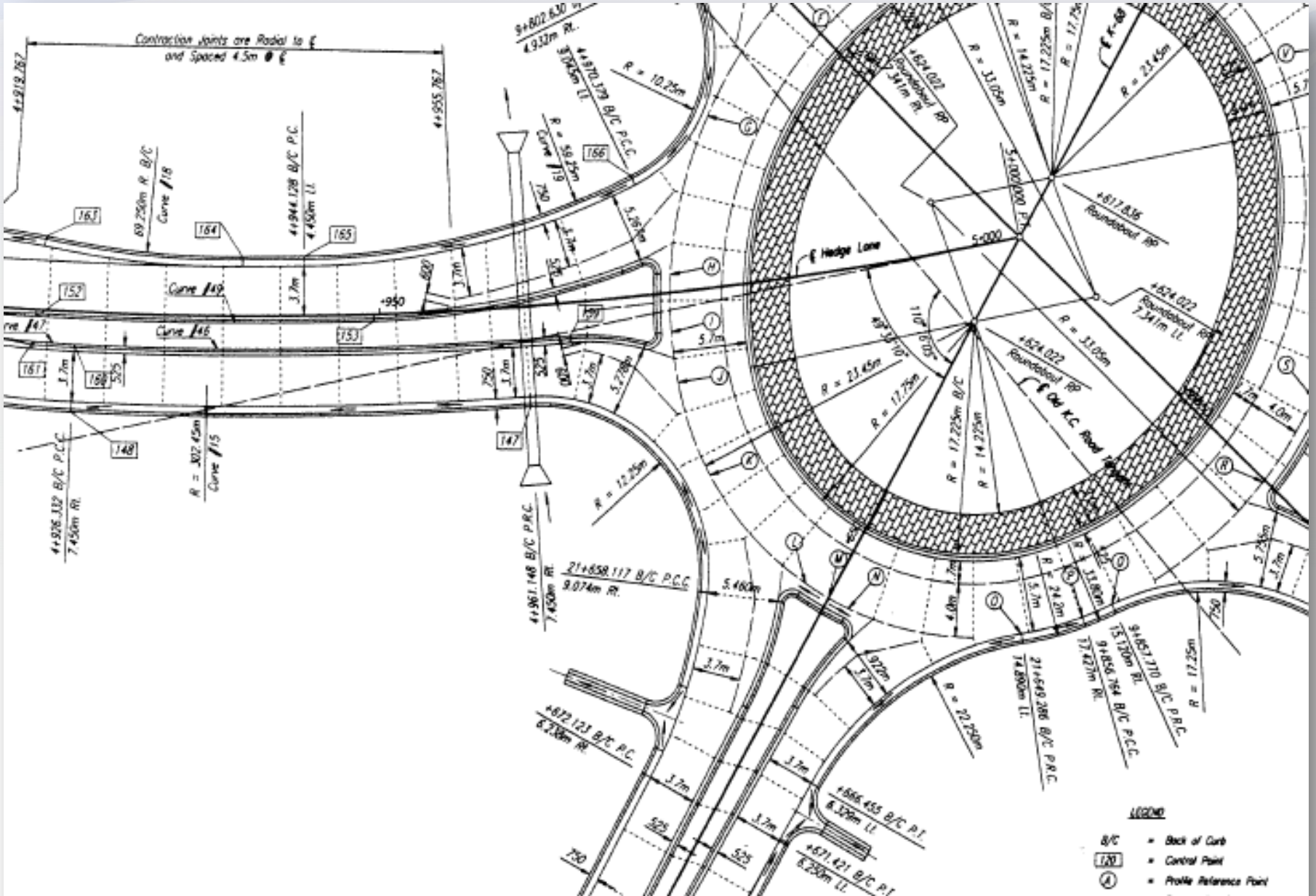
Lining joints perpendicular to pavement edge!

Lincoln Road/ Montana Avenue RAB

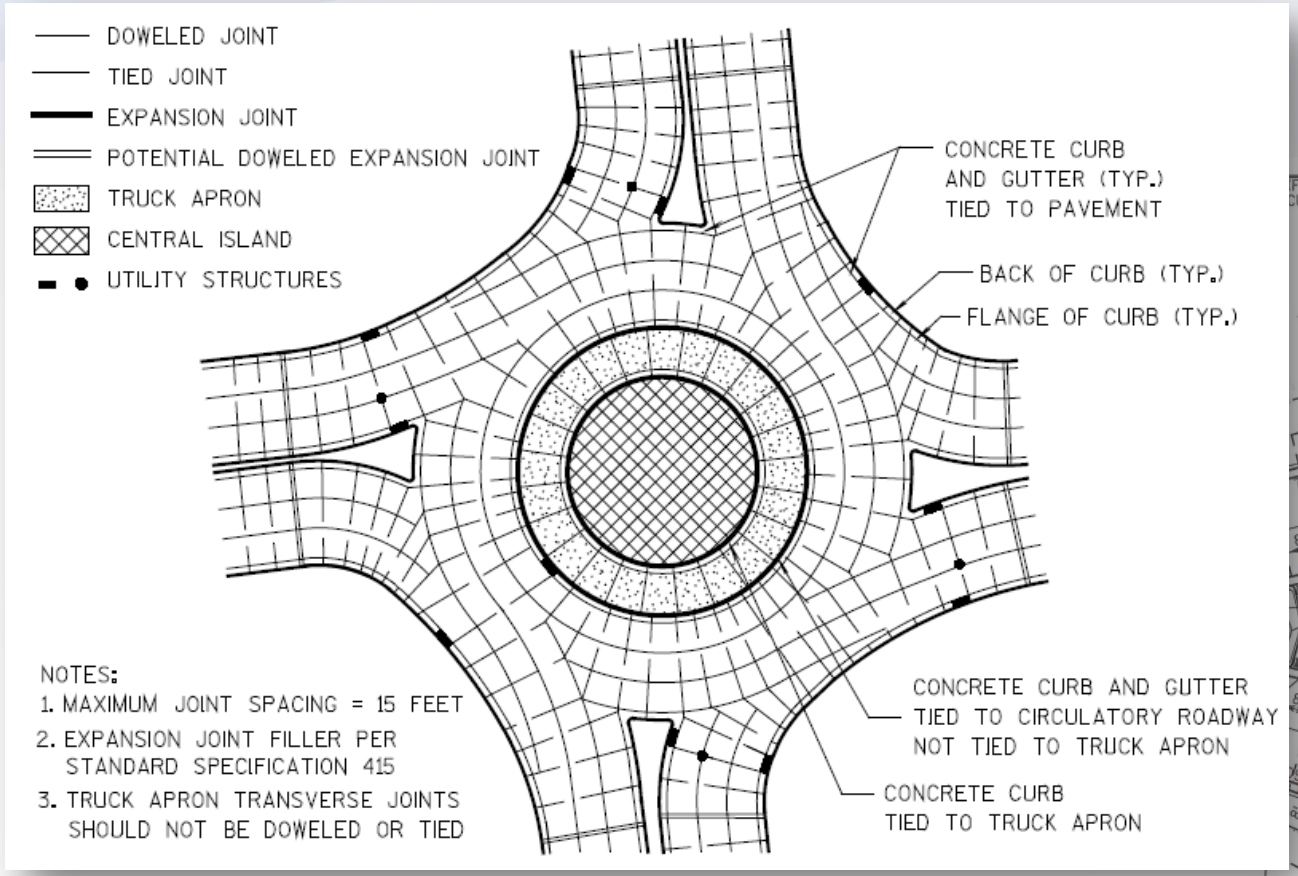


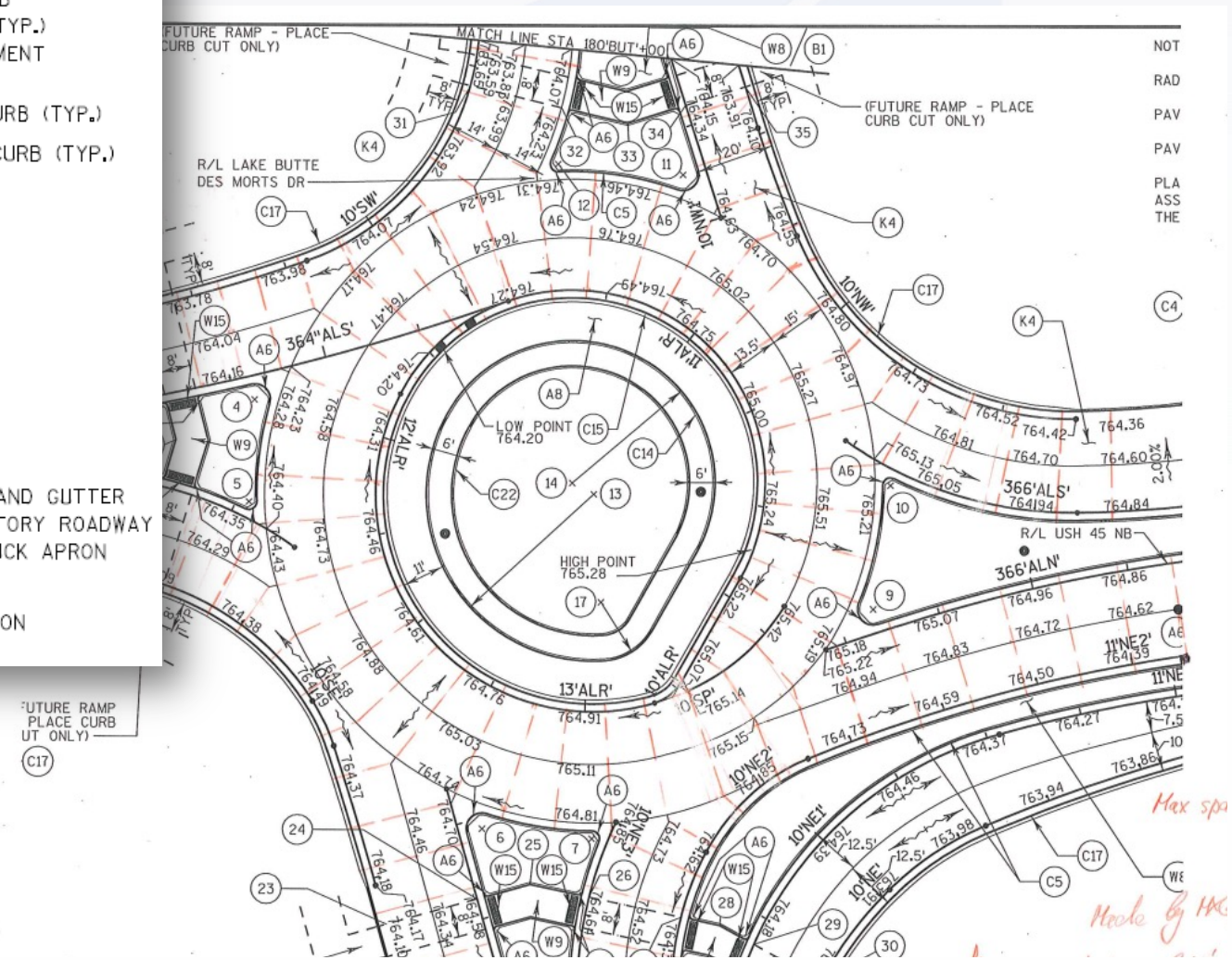
Alternate Design Examples for Roundabouts

Kansas – Oval Shaped



Wisconsin – Pinwheel Method





https://wisconsindot.gov/rdwy/sdd/sd-13c18.pdf#page=1

Minnesota – Fiber Reinforced Jointless

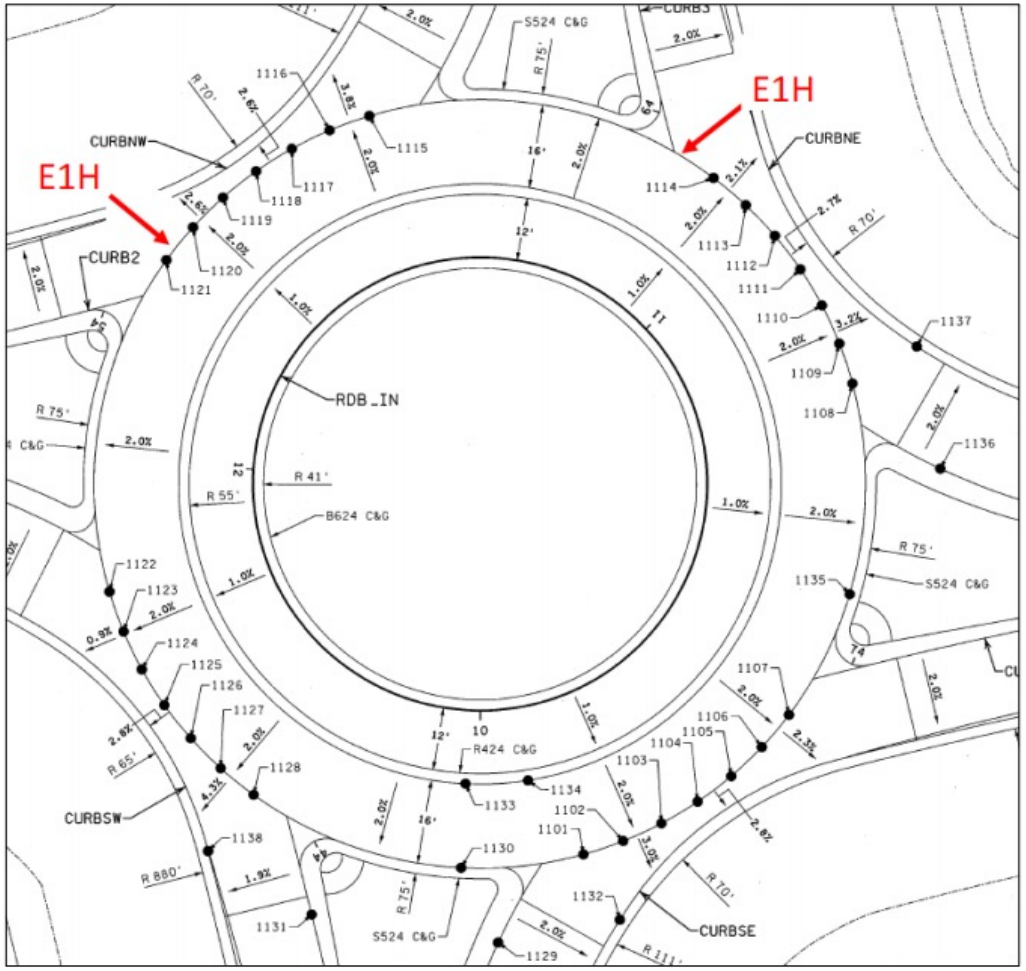


Figure 3- Construction joint E1H (un-doweled) at the outer perimeters of the FRC ring

Figure 16- Using a portable vibrator and the roller screed for concrete placement

Report: http://dot.state.mn.us/mnroad/nrra/structure-teams/rigid/files/frc-roundabout-task-1-construction-report-final.pdf

Minnesota – Fiber Reinforced Jointless

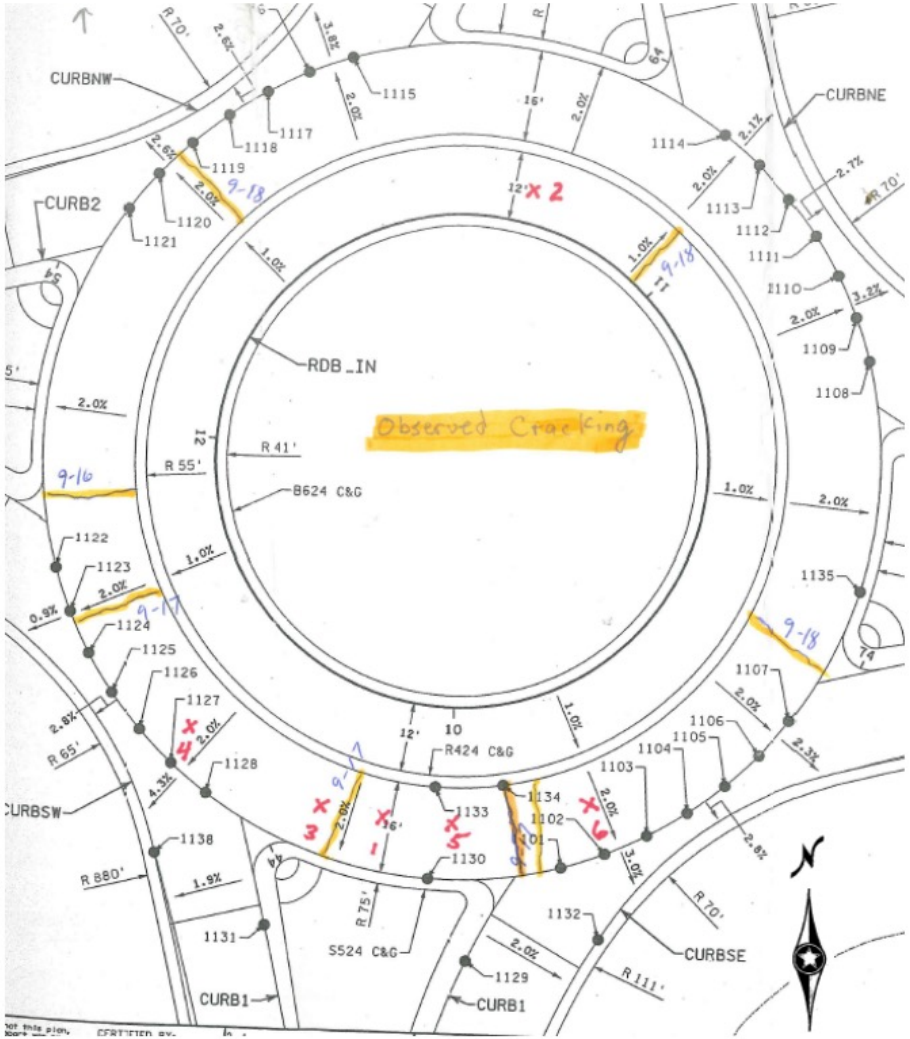


Figure 20- Location of the cores taken from the joint-less FRC roundabout in late September 2018 indicated by red "x" marks

O Street and 35th Avenue RAB – Weld County, CO

O Street and 35th Avenue RAB – Weld County, CO

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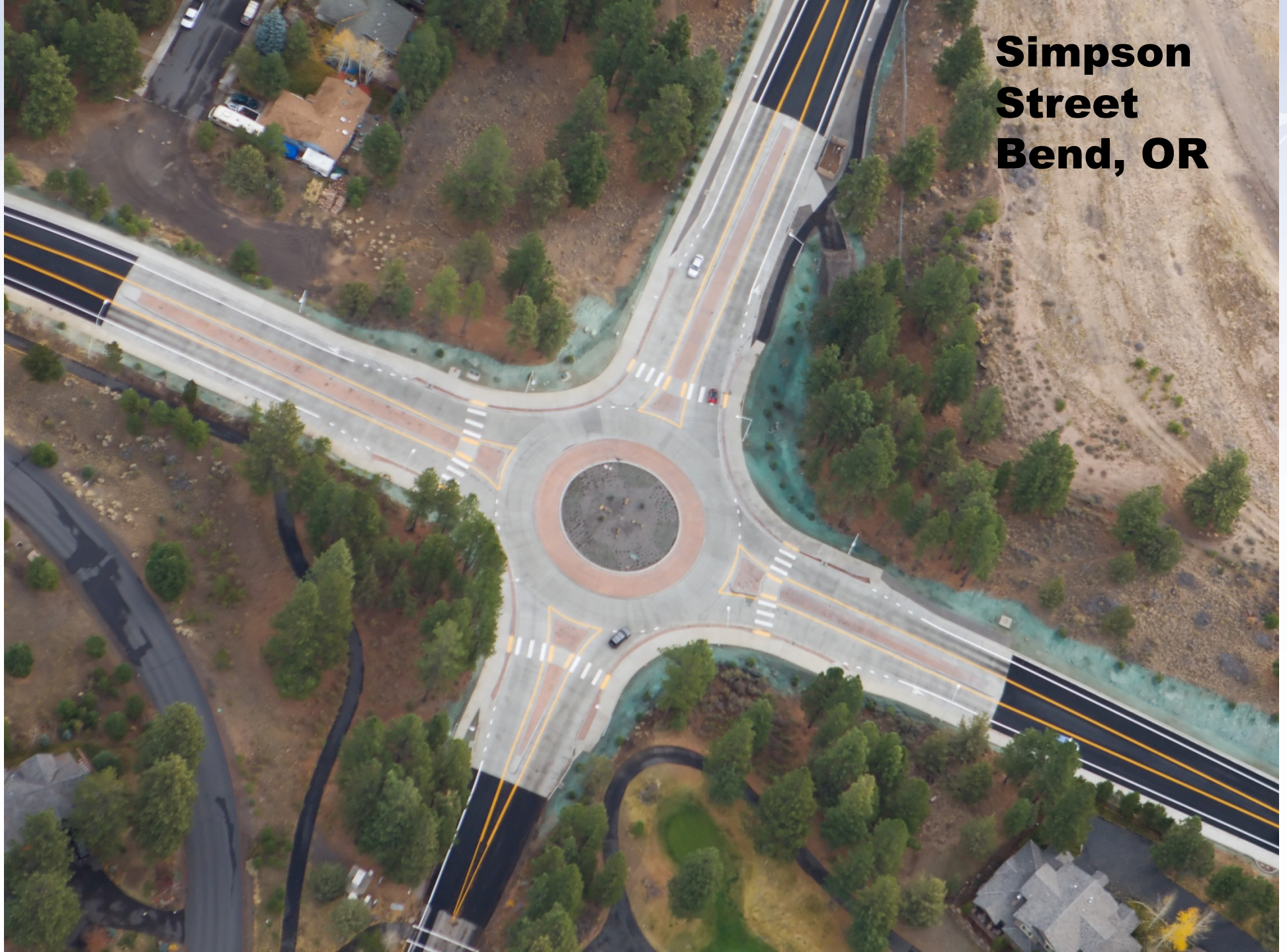
O Street and 35th Avenue RAB – Weld County, CO

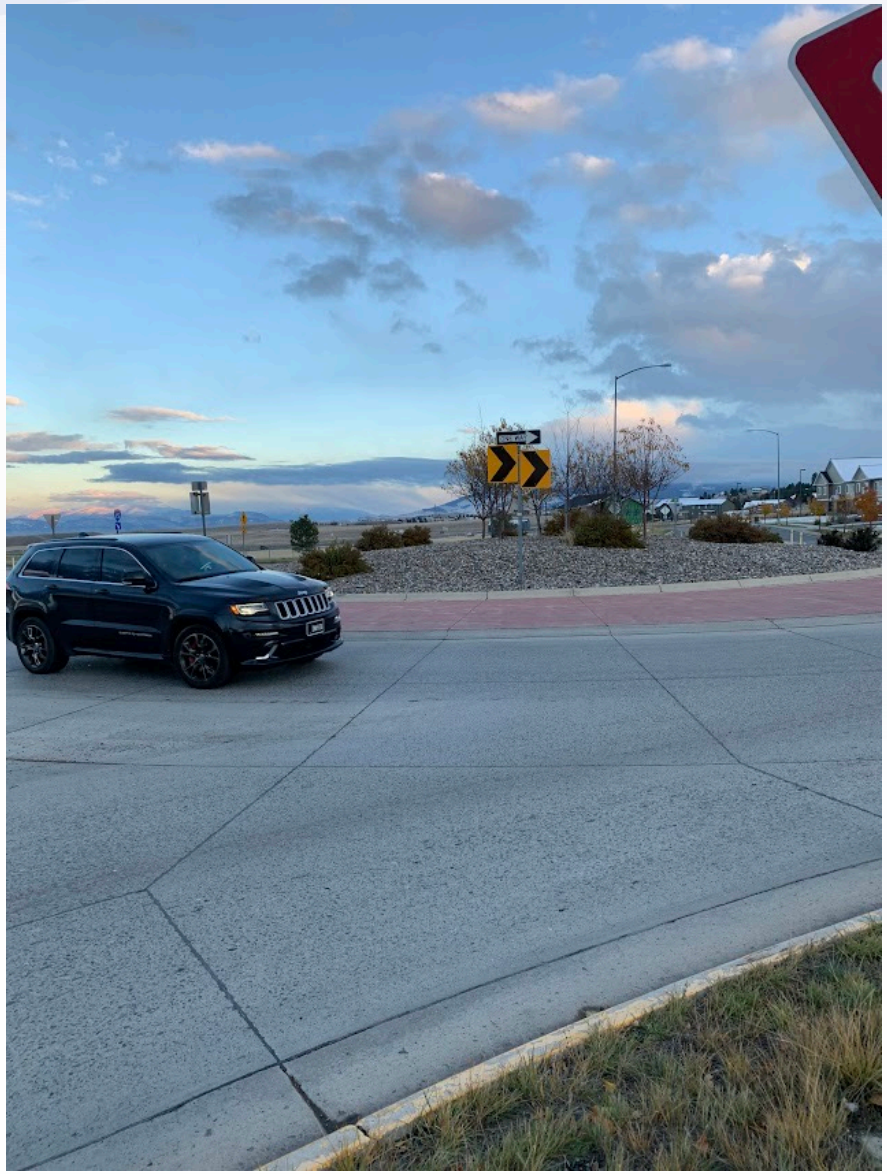

MLK
Springfield, OR

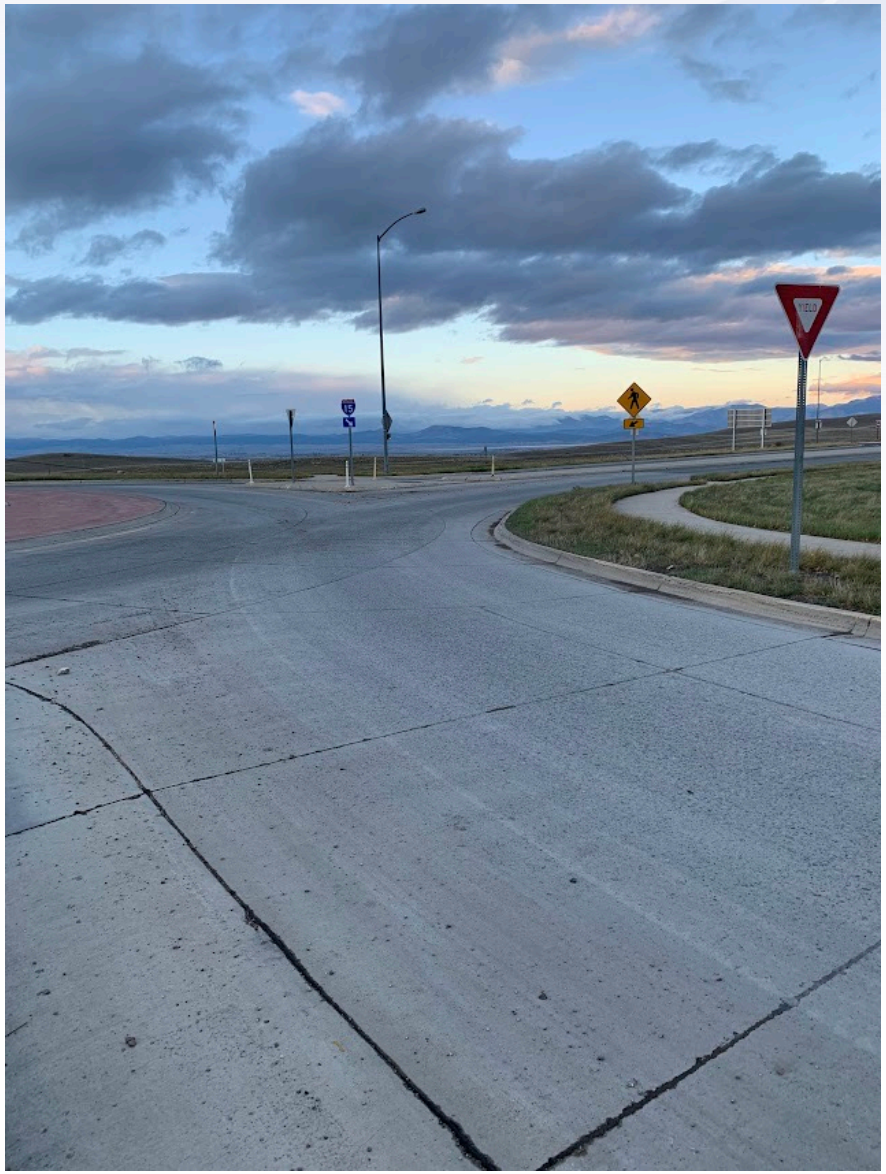

5th Ave & Fruitvale
Yakima, WA

Saint Peter, MN

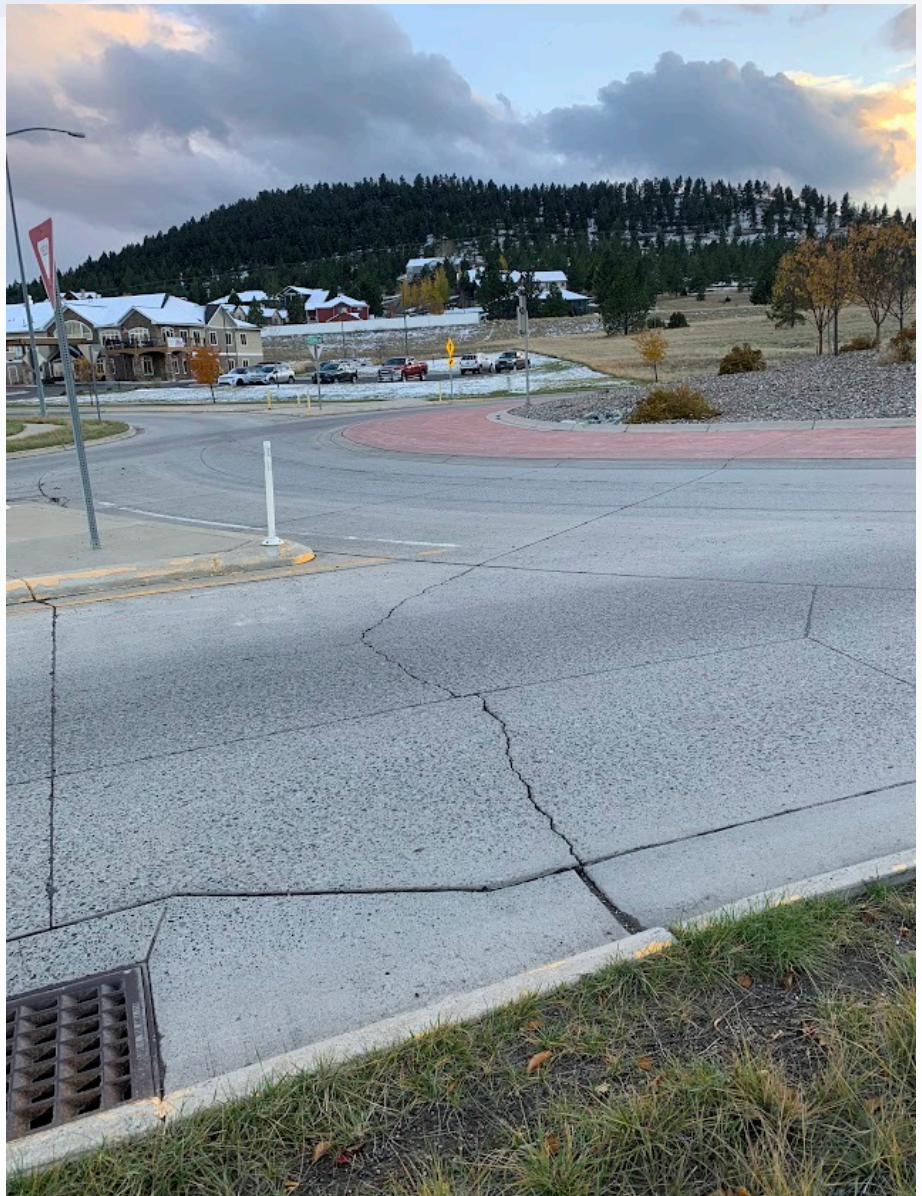

Simpson
Street
Bend, OR

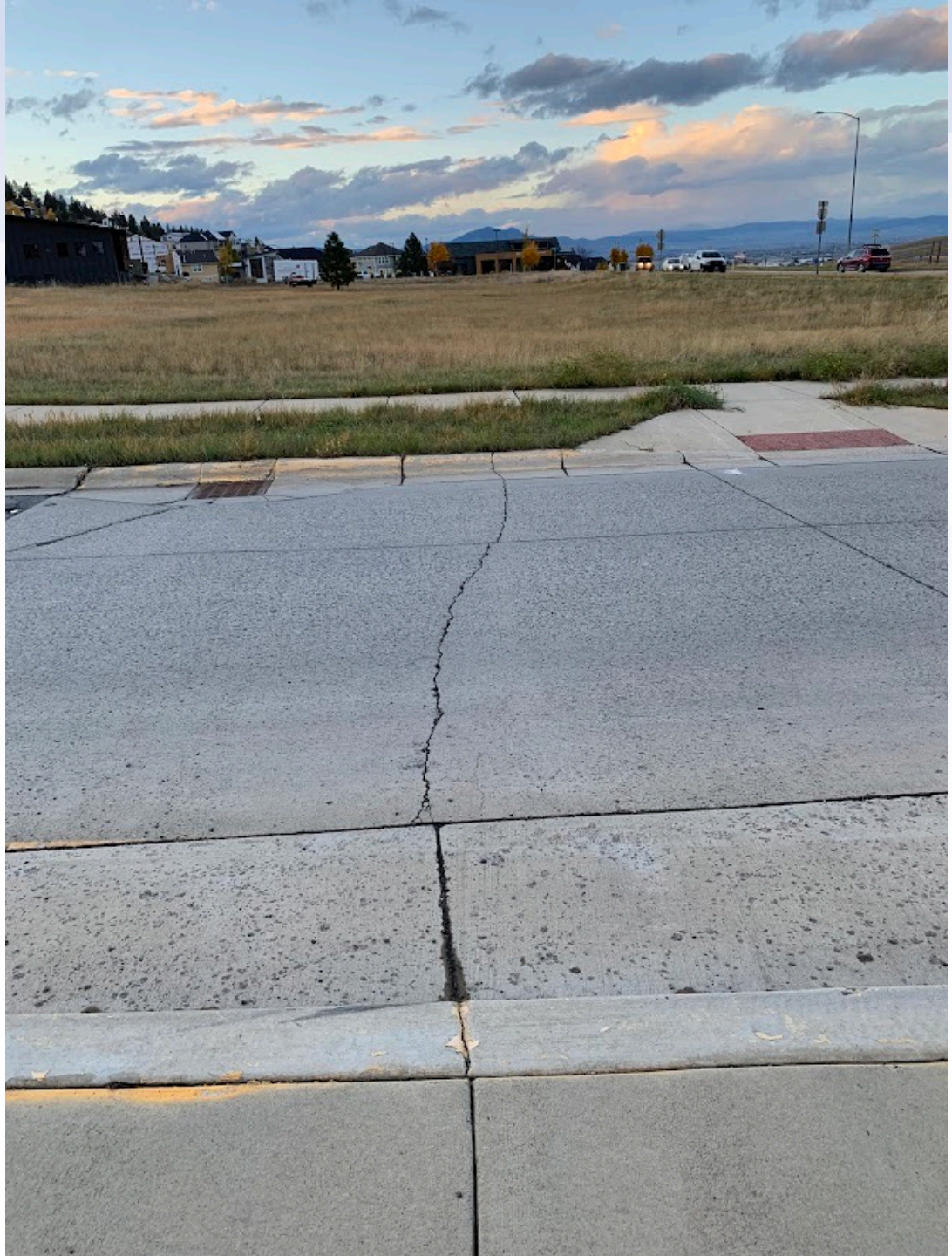
Saddle Drive and I-15 – Helena (2010)





“Sympathy” Cracks





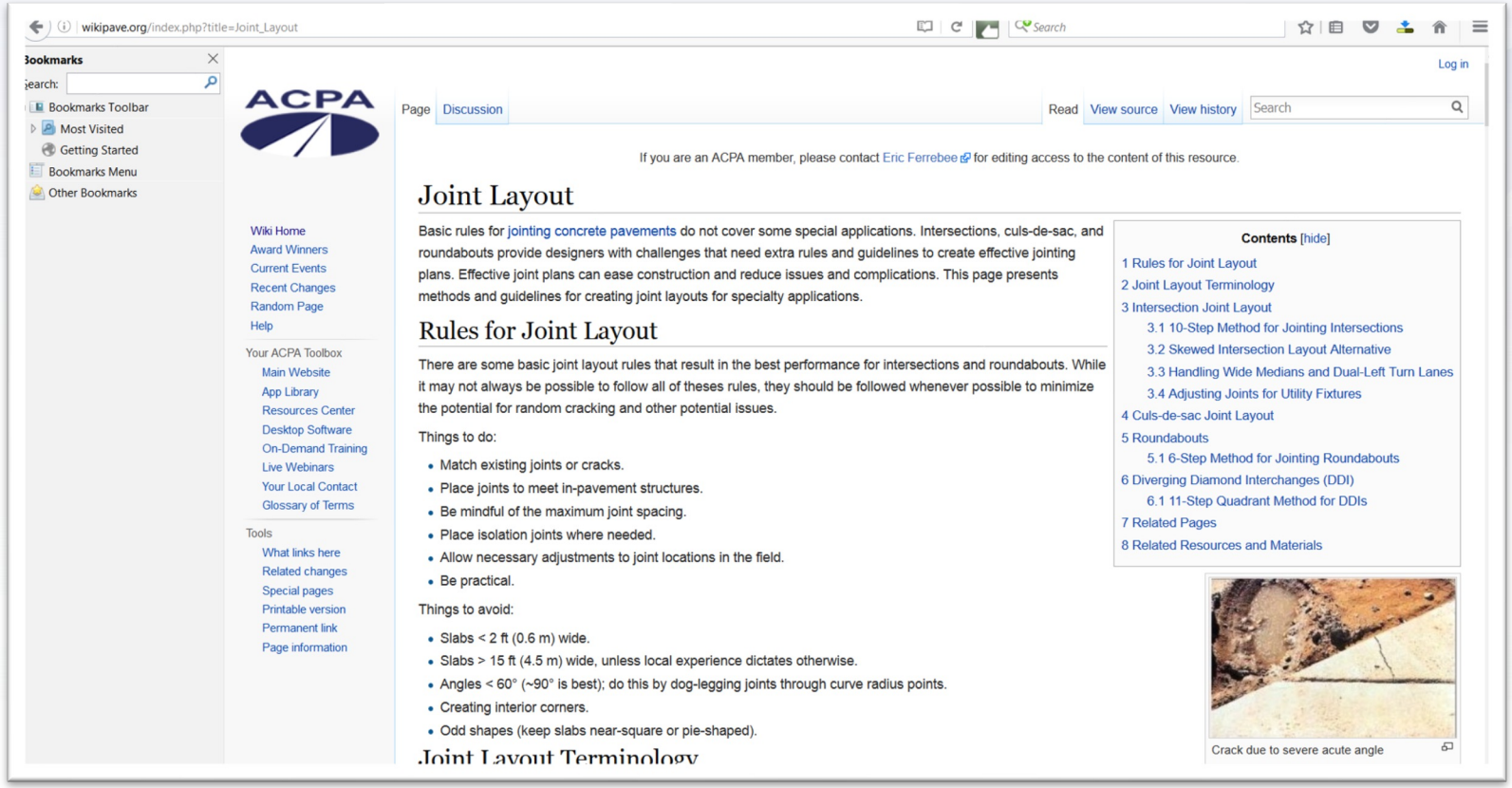

Add expansion joint here

Note – pie shape eliminated

What about Costs

Date	Location	City	State	Section	Quantity SY	Unit cost $/ SY	Extension	Project Cost	Pavement %
Oct-22	US 6/ 5th Street &	Clifton	CO	9" PCCP	12,878	$155.0	$1,996,090		
	US 6 / 15th Street			9 " PCCP special	382	$170.0	$64,940		
				9 " PCCP fast T	420	$175.0	$73,500		
					13,260	**$161.0**	**$2,134,530**	**$16,361,000**	**13%**
Jan-22	Lincoln/ Montana	Helena	MT	9" PCCP	3,575	$144.0	$514,800		
				9 " PCCP color	750	$173.0	$129,750		
					4,325	**$149.0**	**$644,550**	**$9,688,000**	**7%**
Jan-22	Ten Mile/ Victory	Meridian	ID	9" PCCP	6,030	$97.3	$586,719		
				9 " PCCP special	410	$101.0	$41,410		
					6,440	**$97.5**	**$628,129**	**$7,400,000**	**8%**
Jan-22	35th and O Street	Greeley	CO	9" PCCP	18,475	$79.5	$1,468,947		
				9 " PCCP color	730	$101.7	$74,226		
				9 " PCCP special	500	$99.9	$49,960		
					19,705	**$80.8**	**$1,593,133**	**$7,404,000**	**22%**
May-21	Mill Prkwy/ Butterfield Rd.	Yakama	WA	9" PCCP	2,920	$70.5	$205,860		

Resources



http://wikipave.org

ACPA Concrete Roundabouts – June 2005, RT 6.03

Resources

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

Iowa SUDAS
STATEWIDE URBAN DESIGN AND SPECIFICATIONS

5G-6

Design Manual
Chapter 5 - Roadway Design
5G - PCC Pavement Joints

Jointing Concrete Roundabouts

A. General Information

Roundabouts are an increasingly popular intersection type due to their traffic flow and safety characteristics. When using concrete for the roundabout, it is critical to develop a workable jointing plan to make sure the joint layout will be constructed properly. The jointing plan is the key by which the joints will be correctly located. Because concrete jointing is sometimes used for lane delineation, it is important to recognize the impact of the jointing plan on drivers who are unfamiliar with the operation of roundabouts.

NCHRP
Research Report 1043

National
Cooperative
Highway
Research Program

Guide for Roundabouts

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REPORT 674

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities

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NRMCA Resources

- Design Assistance Program
- Jointing Plan Assistance
- www.paveahead.com - case studies
- www.pavementdesigner.org

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