Back to Basics: Jointing Concrete Pavements

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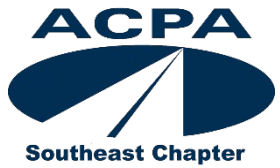

Questions?

- Questions are encouraged. Please enter your questions (and answers) in the question box and we will share the Q & A electronically following the webinar
- PDH certificates will be sent to participants electronically
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2026 Webinar Program

- Topics coming in future 2026 webinars:
  - QC and process control
  - Early opening strength for pavements
  - Concrete overlays at GA airports
  - Non-destructive testing
  - Preservation, repair and rehab
  - …and more!
- Look out for announcements with future dates and presenters
- Details will also be posted at:

www.acpa.org/webinars/

About the Presenters

- **Eric Ferrebee** is the Senior Director of Technical Services with the American Concrete Pavement Association, having joined the association in 2014
- He is responsible for providing technical resources, tech transfer and consulting services to ACPA members and the agencies and owners they serve
- He is a key team member in the industry's efforts related to competition, sustainability, resilience, pavement design, and construction.
- Eric earned both his Bachelor's and Master's in Civil Engineering from the University of Illinois at Urbana-Champaign and is registered as a P.E. in Illinois

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About the Presenters

- **Dan King** is an Associate Director at the CP Tech Center at Iowa State University, having joined the center in 2021
- He manages tech transfer activities and in-house research projects for the center, working to help educate the concrete pavement community, implement new technologies, and improve the state of concrete paving practice
- Dan earned his Bachelor's and Master's in Civil Engineering from the University of Illinois at Urbana-Champaign, his PhD from Iowa State University, and is registered as a P.E. in Iowa

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Learning Objectives

- Identify the different types of joints used for concrete pavements
- Utilize step-by-step methods to develop a joint layout for intersections or roundabouts
- Determine what needs to be done with a dead-end joint
- Identify different design methods for concrete roundabouts
- Understand the factors that impact the sawing window for concrete pavements

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Today’s Presentation

- Introduction & Types of Joints
- Design & Layout
- Construction
- Durability

Introduction & Types of Joints

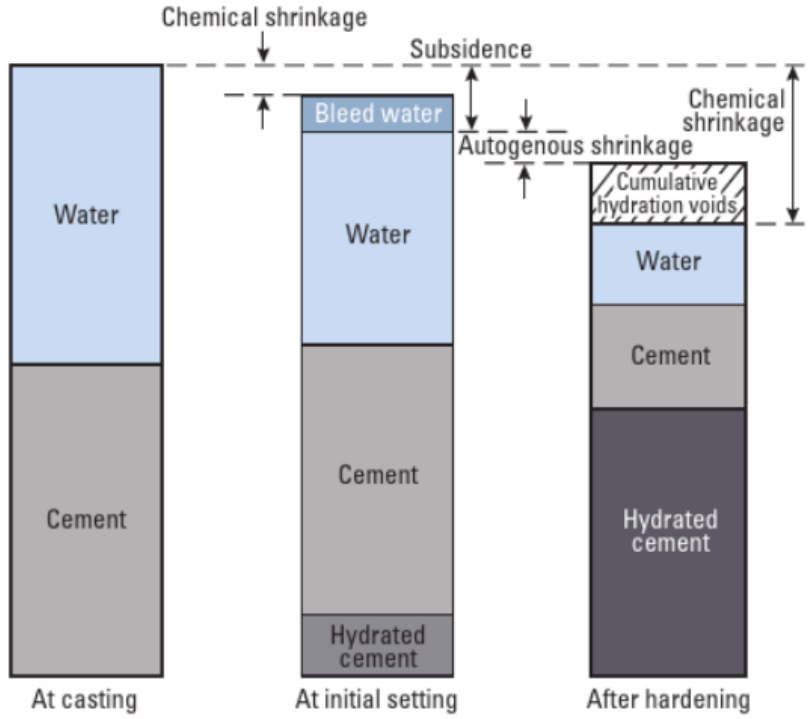
Why Place Joints in Concrete Pavements?

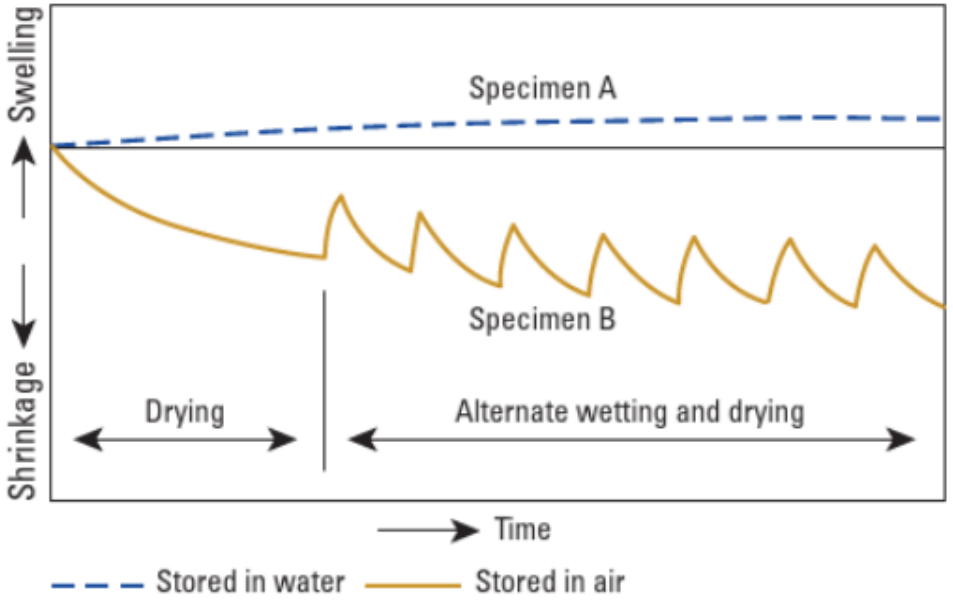
- If we place concrete pavements without joints, they will crack!

- Old US 20, Moville, IA
  - Built in 1921
  - No joints – crack pattern developed on its own

Why Place Joints in Concrete Pavements?

- Concrete begins to shrink shortly after placement
  - Natural result of the hydration reaction, reduction in temperature, and loss of moisture from the system





Images: ACA

Why Place Joints in Concrete Pavements?

- If concrete slabs could expand and contract freely, shrinkage wouldn't cause any problems
- However, restraint from the underlying subgrade or subbase causes tensile stresses to develop in the slab as it contracts

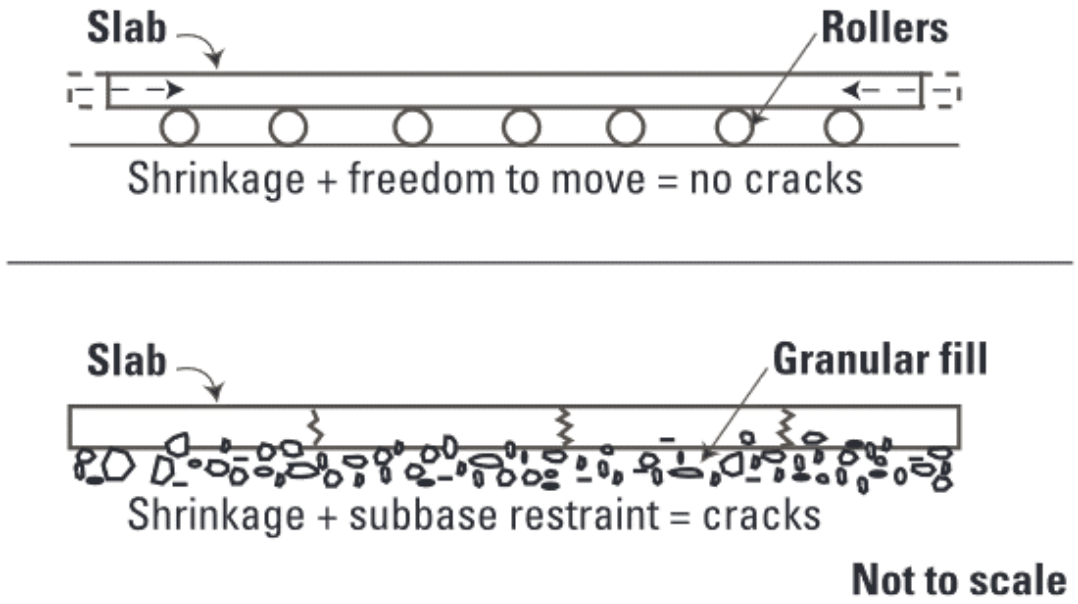
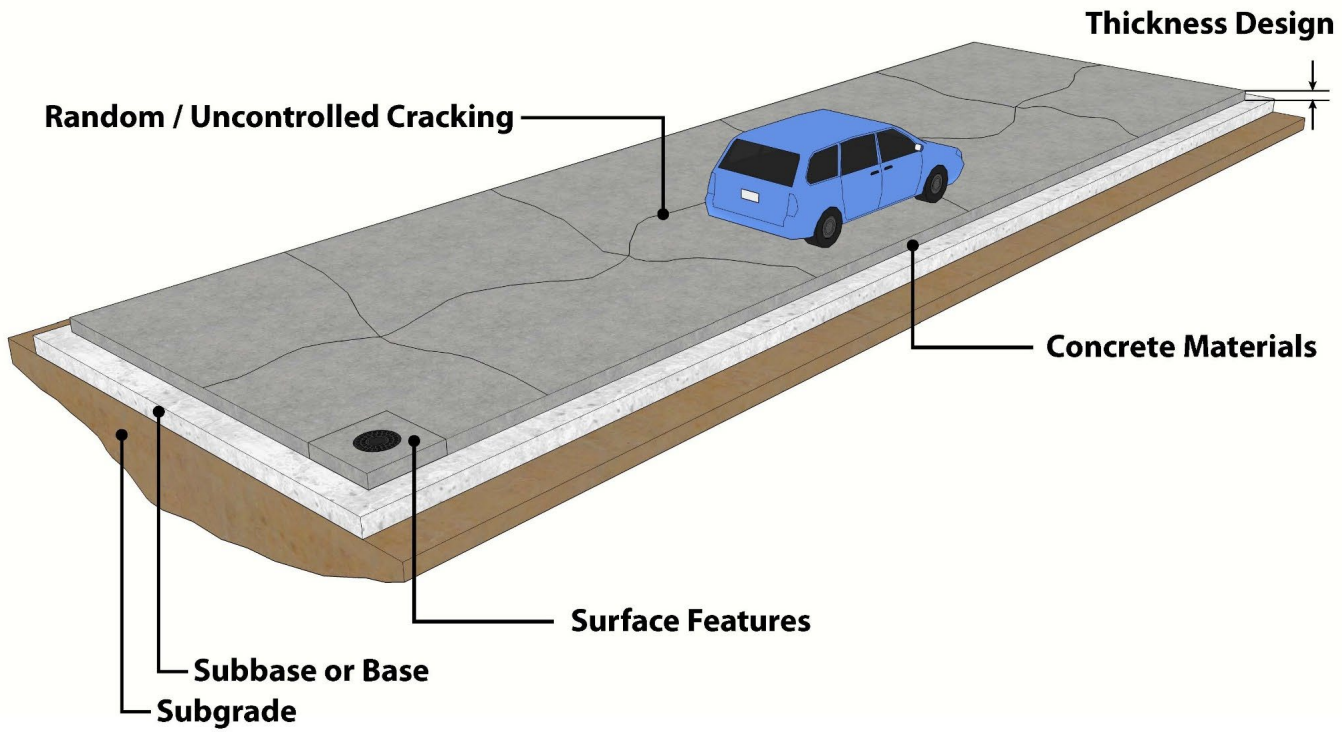


Image: ACPA

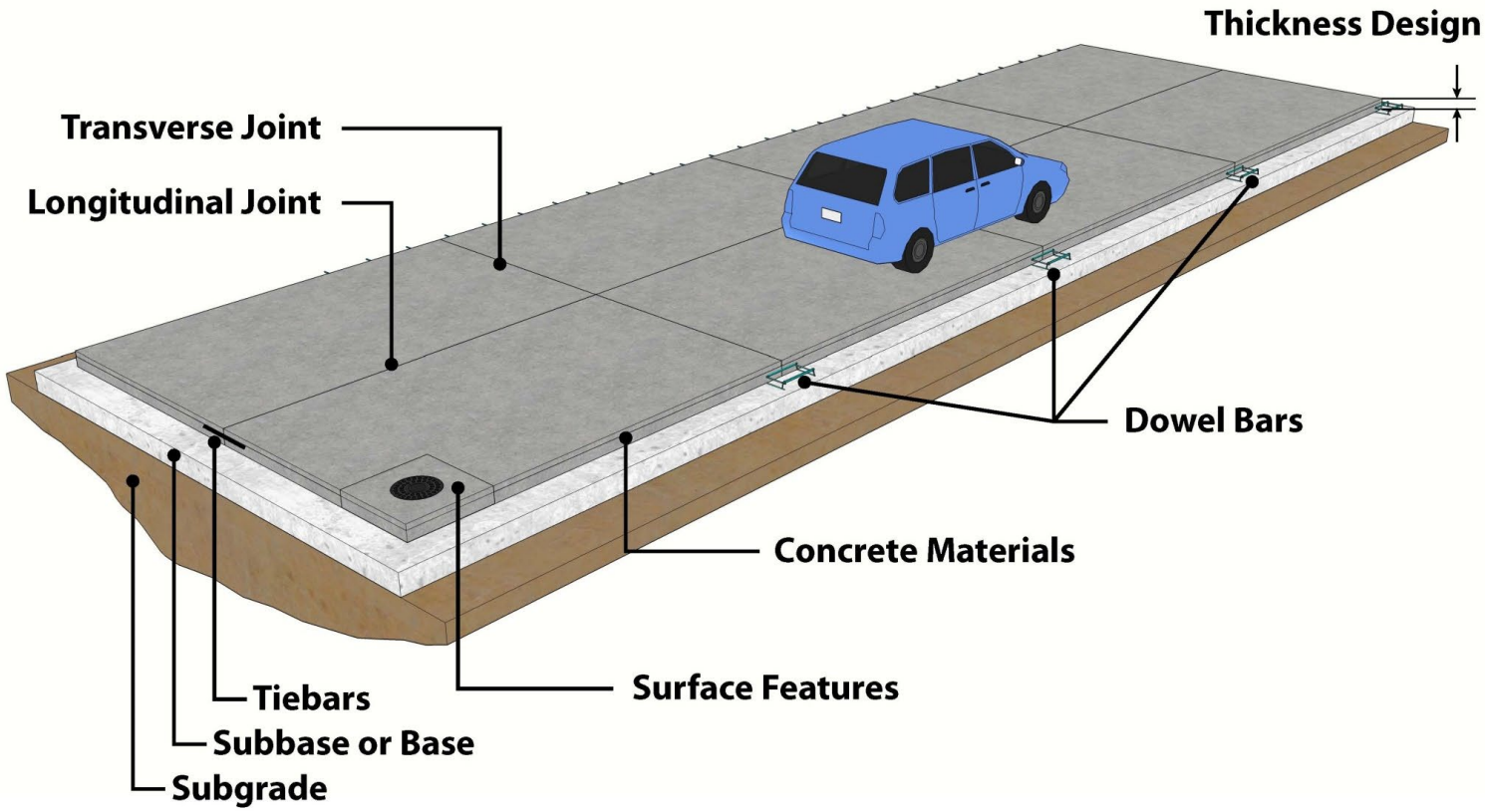
Why Place Joints in Concrete Pavements?

- Concrete gains strength as it hydrates, but eventually these tensile stresses will exceed the concrete strength, and random cracks will develop in the pavement



Why Place Joints in Concrete Pavements?

- We place joints in concrete pavements to direct the formation of cracks at planned locations and to control cracking behavior



Types of Joints

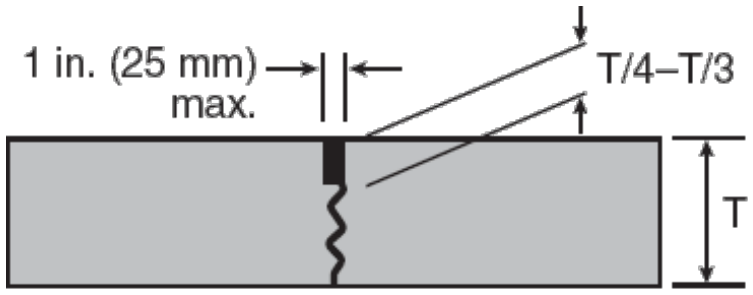
- Vehicles cross transverse joints
  - Load transfer across transverse joints is a key factor in concrete pavement performance
- Longitudinal joints are parallel to the direction of traffic
  - Frequently coincide with lane lines on streets and roads
- In parking lots without channelized traffic, we may not distinguish between transverse and longitudinal joints

Types of Joints

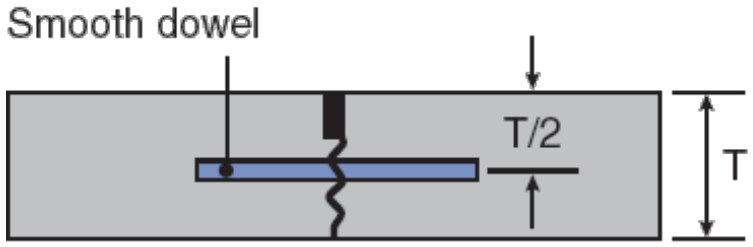
- Primary joint types:
  - Contraction
  - Construction
  - Isolation or Expansion
- Each of these joints can be transverse or longitudinal

Contraction Joints

- Transverse contraction joints
  - Formed by saw cuts that create a weakened plane to direct the formation of cracks at planned locations

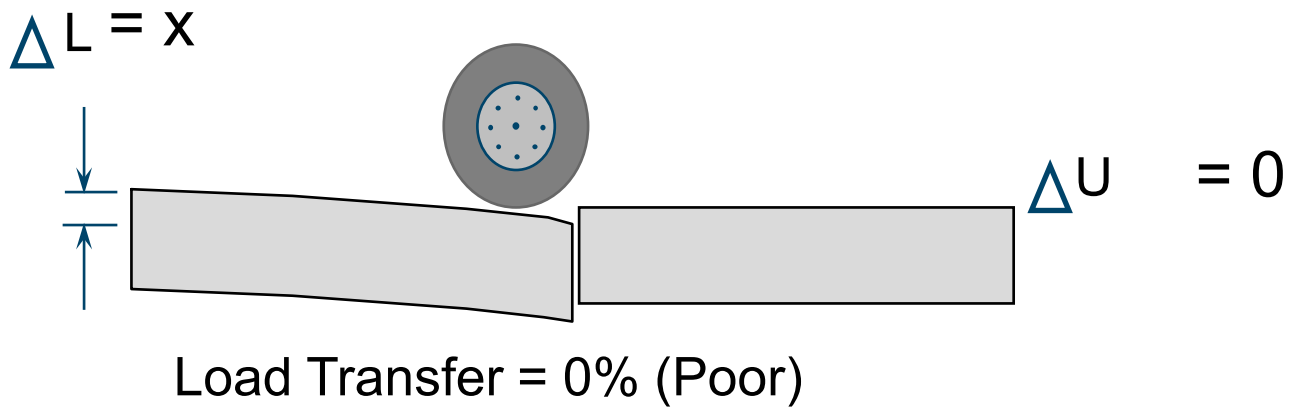


Undoweled – Transverse (Type A-1)

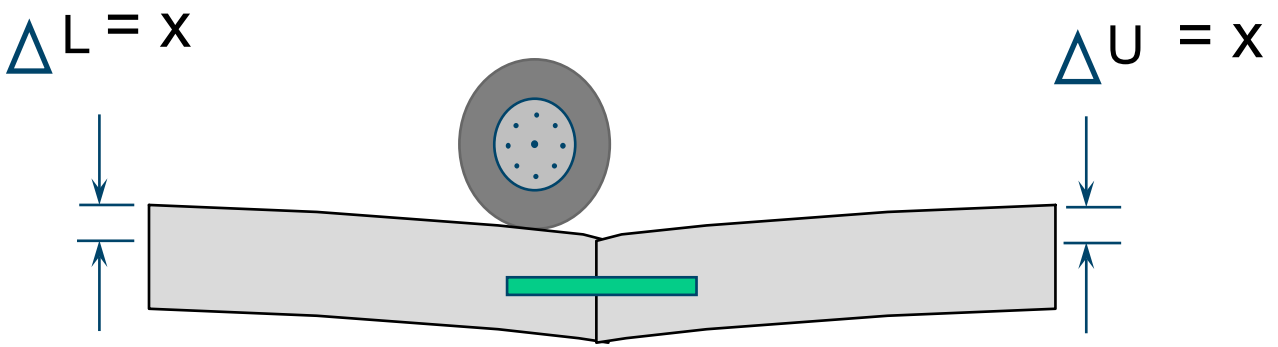


Doweled – Transverse (Type A-2)

Load Transfer



Load Transfer = 0% (Poor)



Load Transfer = 100% (Good)

Image: ACPA

Load Transfer

- In the absence of dowel bars, aggregate interlock provides shear load transfer across the joint
  - Function of aggregate properties (including size, shape, and hardness), mix properties, and joint opening

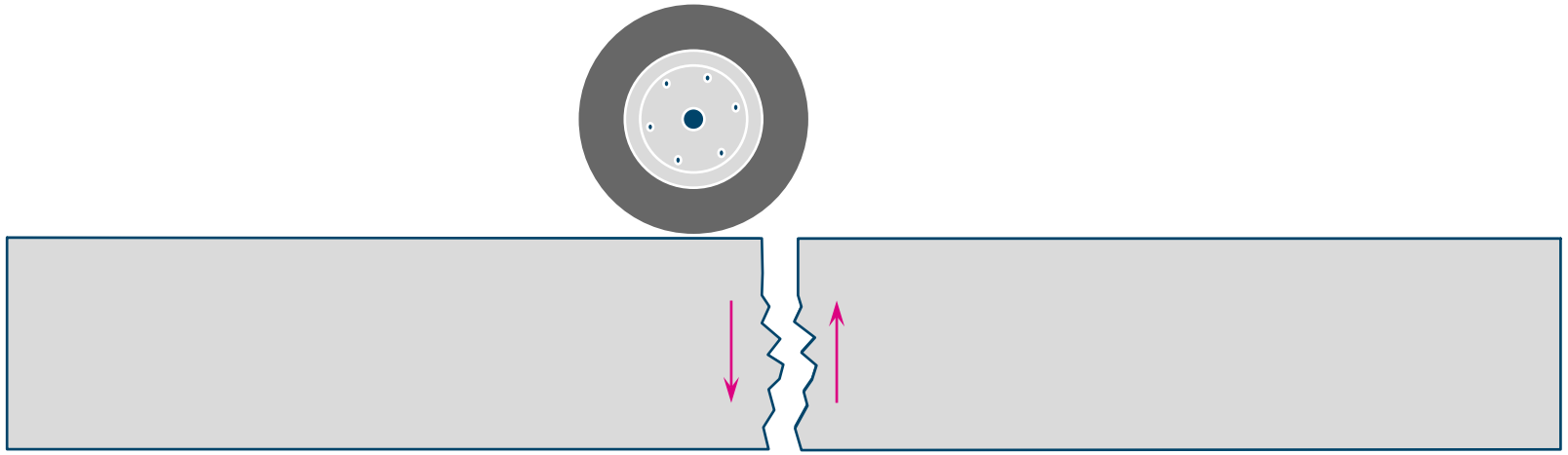


Image: ACPA

Load Transfer

- When a pavement carries a high volume of heavy traffic loads, aggregate interlock will not provide sufficient load transfer
- Upon reaching about 100 trucks/day, we reinforce transverse joints with dowel bars for additional load transfer

Image: FHWA

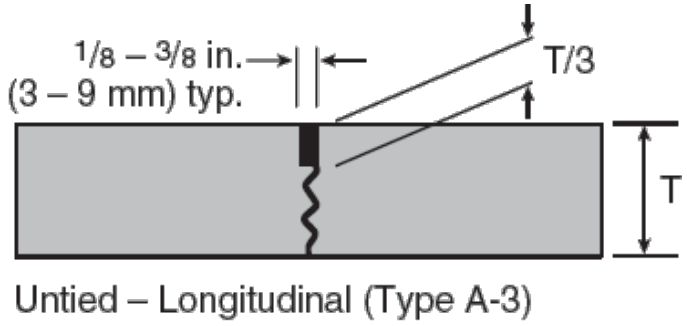
Dowel Bars

- Epoxy-coated solid steel dowel bars are most common
  - Other dowel materials include stainless steel, fiberglass-reinforced polymer (FRP), and galvanized or coated steel
- Diameter is frequently specified as a function of slab thickness

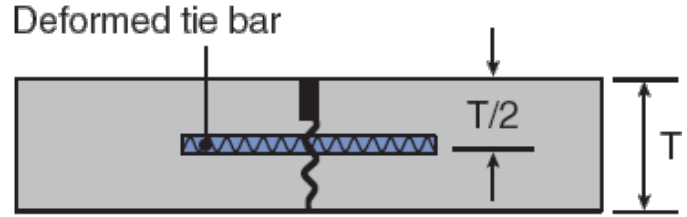
Images: Avient

Contraction Joints

- Longitudinal contraction joints
  - Tie bars are used to tie lanes together
  - Diameter and spacing are generally specified as a function of slab thickness



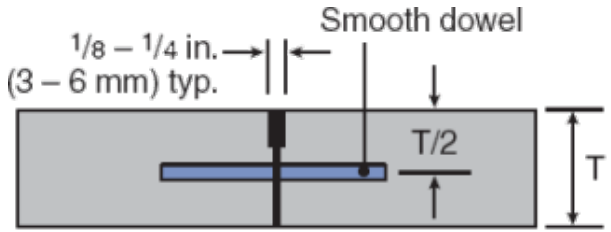
Untied – Longitudinal (Type A-3)



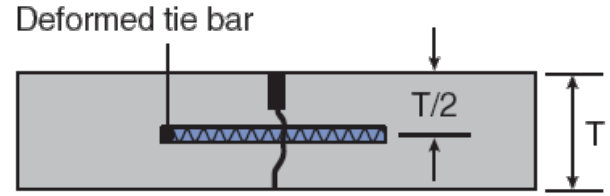
Tied – Longitudinal (Type A-4)

Construction Joints

- Transverse construction joints (headers)
  - Occur at ends of pavement sections
  - Locations are unplanned on mainline street & roadway pavements



Doweled butt – Transverse (Type B-1)

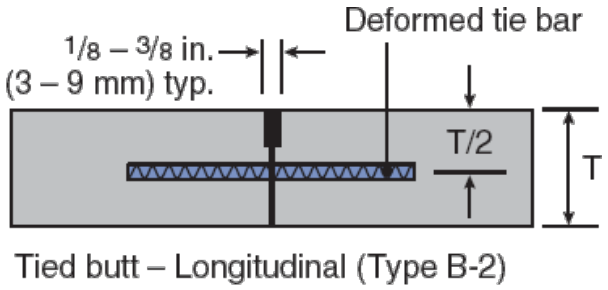


Tied – Transverse (Type C-1)
(Keyway optional)

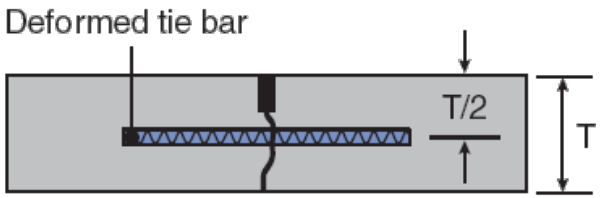
Images: ACPA

Construction Joints

- Longitudinal construction joints
  - Occur when paving lanes are placed in separate passes



Tied butt – Longitudinal (Type B-2)

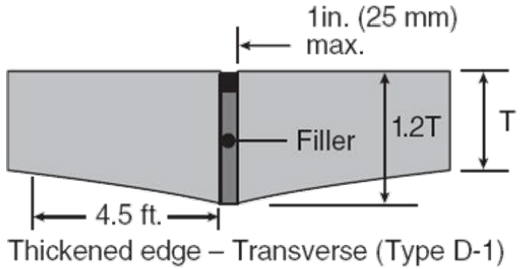


Keyed – Longitudinal (Type C-2)
(Deformed tie bar optional)

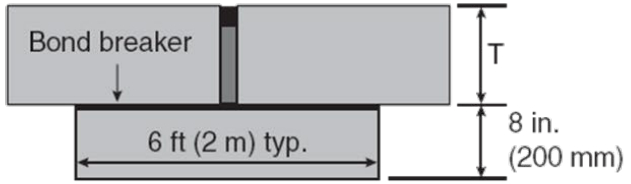
Images: ACPA

Isolation or Expansion Joints

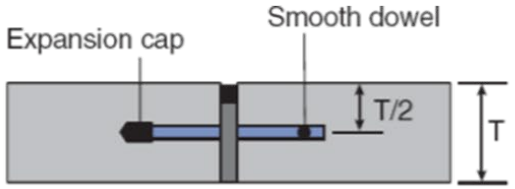
- Used to isolate structures within or adjacent to the pavement
- Also used to mitigate cracking potential when adjacent roadway sections come together at intersections and roundabouts



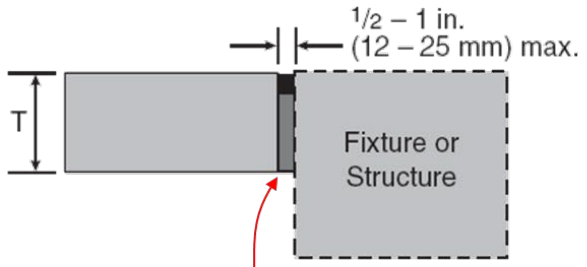
Thickened edge – Transverse (Type D-1)



Sleeper slab – Transverse (Type D-3)

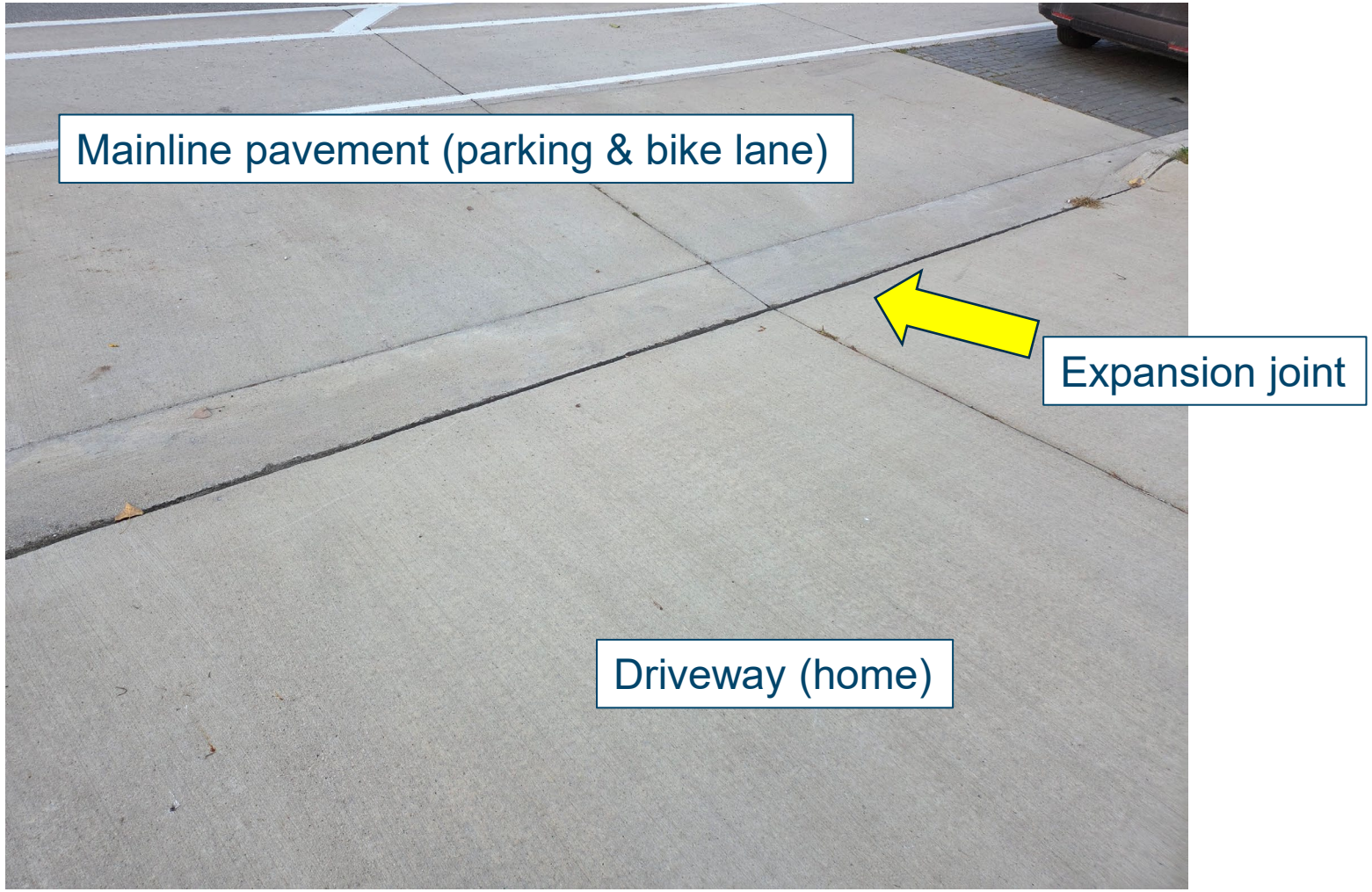


Doweled – Transverse (Type D-2)



Undoweled – Longitudinal (Type D-4)

Isolation or Expansion Joints



Design & Layout

Construction

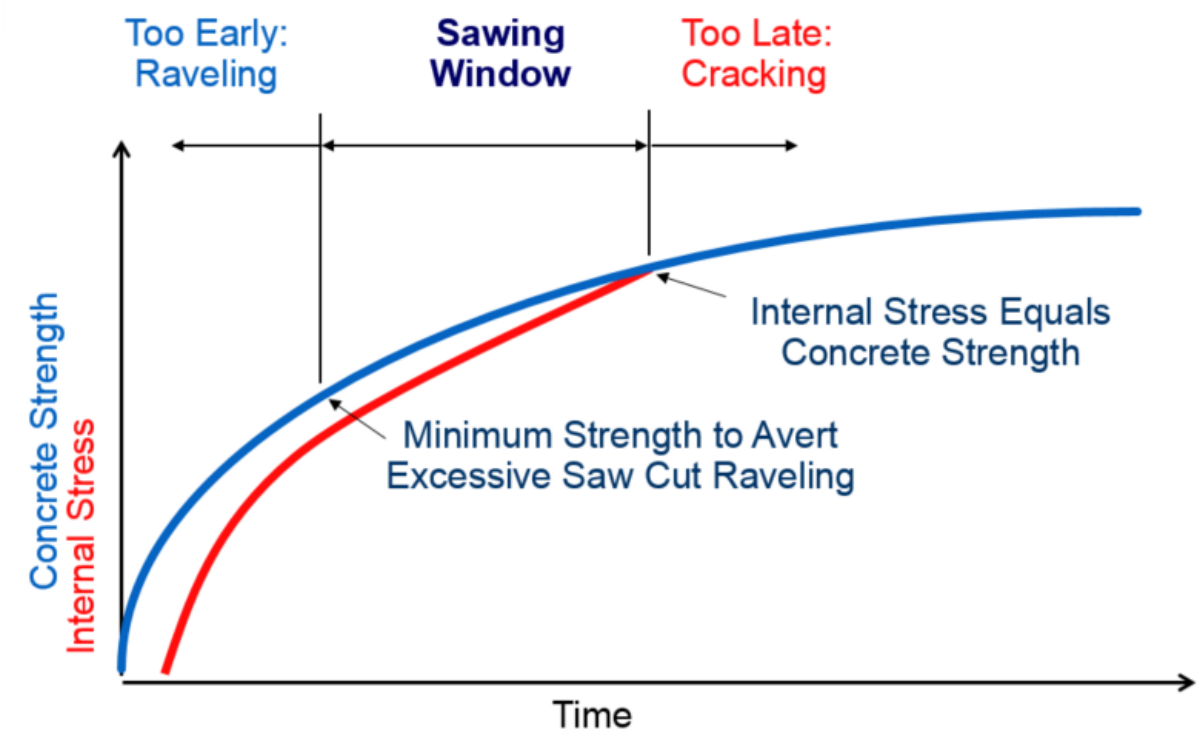
Joint Sawing

- To establish the jointing system to meet our requirements, we need to saw joints at the proper timing and depth

R Image: ACA

Timing of Joint Sawing

- Joint sawing must be done in the sawing window
  - Period where concrete is strong enough to saw without raveling or spalling, and before tensile stresses exceed strength

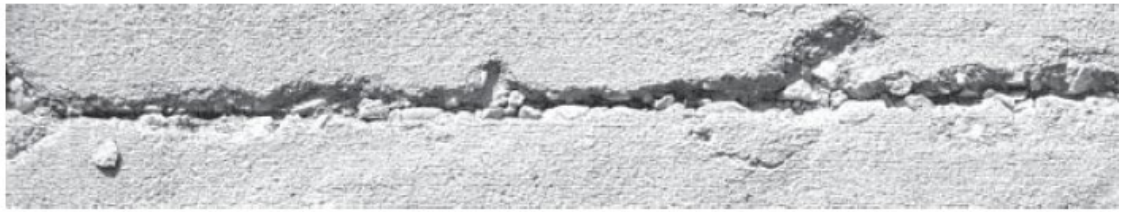


- Conventional saws
  - Window starts about 4 to 12 hours after placement
- Early-entry saws
  - Window starts from 1 to 4 hours after placement

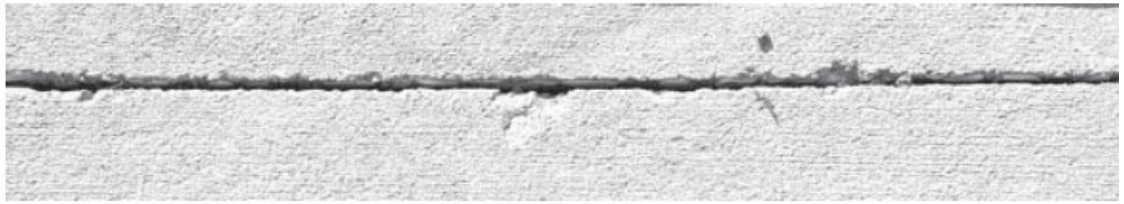
Image: ACPA

Timing of Joint Sawing

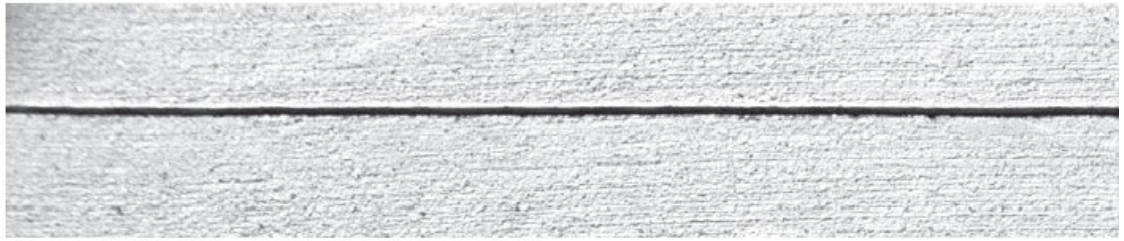
- Joint sawing must be done in the sawing window
  - Period where concrete is strong enough to saw without raveling or spalling, and before tensile stresses exceed strength



A. UNACCEPTABLE RAVELING - Sawed too early



B. MODERATE RAVELING - Sawed early in window



C. NO RAVELING - Sawed later in window

Depth of Joint Sawing

- Joints must be sawed deep enough to weaken the plane and ensure the cracks form at the saw cut locations
- Note differences in specifications for:
  - Transverse vs. longitudinal joints
  - Doweled vs. un-doweled transverse joints
  - Early-entry vs. conventional saws

Conventional saw

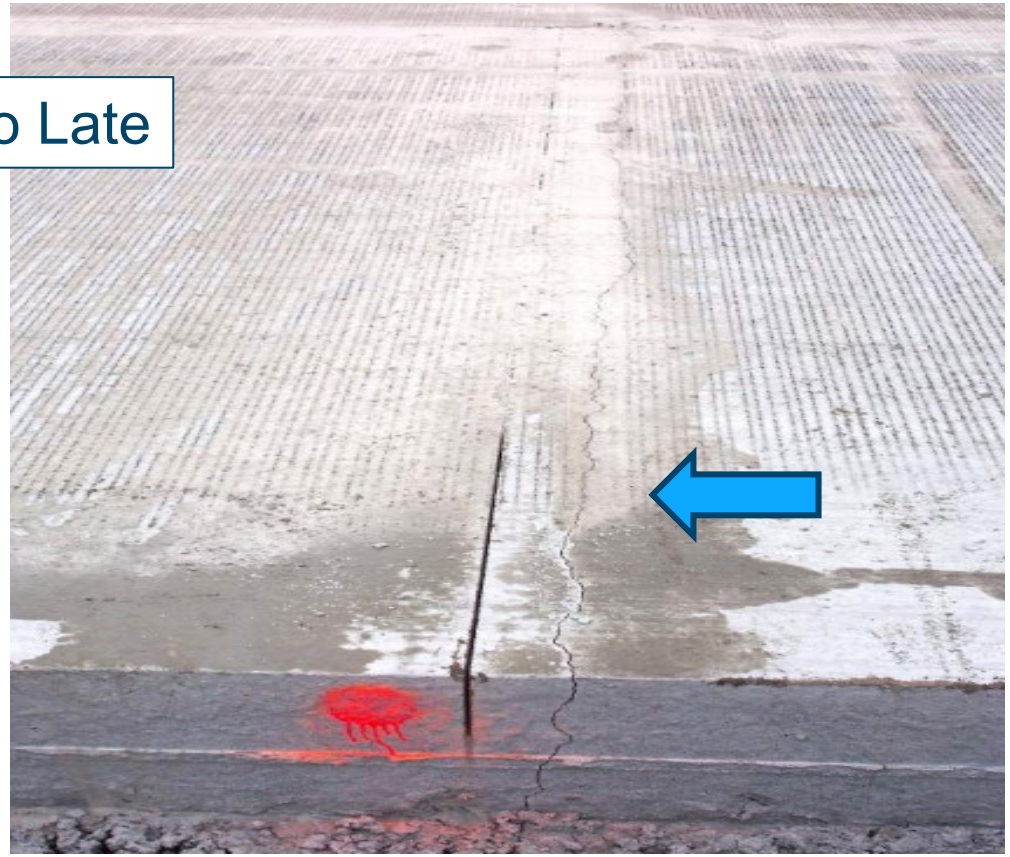
Early-entry saw

Images: Iowa DOT

Troubleshooting Joint Sawing Issues

- Cracking due to joint sawing issues:

Too Late



Too Shallow

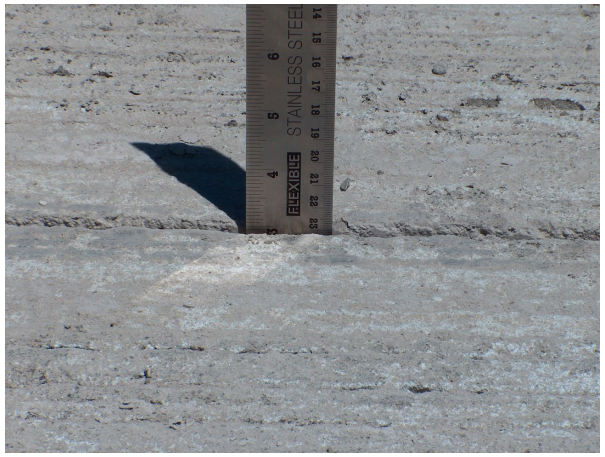
R Image: Jerod Gross

Troubleshooting Joint Sawing Issues

- The sawing window is sensitive to many factors:
  - Temperature changes can speed up or delay set time, shifting the window
  - A sharp temperature decrease late in the day or overnight can lead to more slab contraction, narrowing the window
  - Windy, sunny, or dry conditions can lead to a greater amount of evaporation, narrowing the window
  - Concrete mixtures with higher Portland cement contents and higher water contents (greater w/cm) experience more shrinkage, narrowing the window

Troubleshooting Joint Sawing Issues

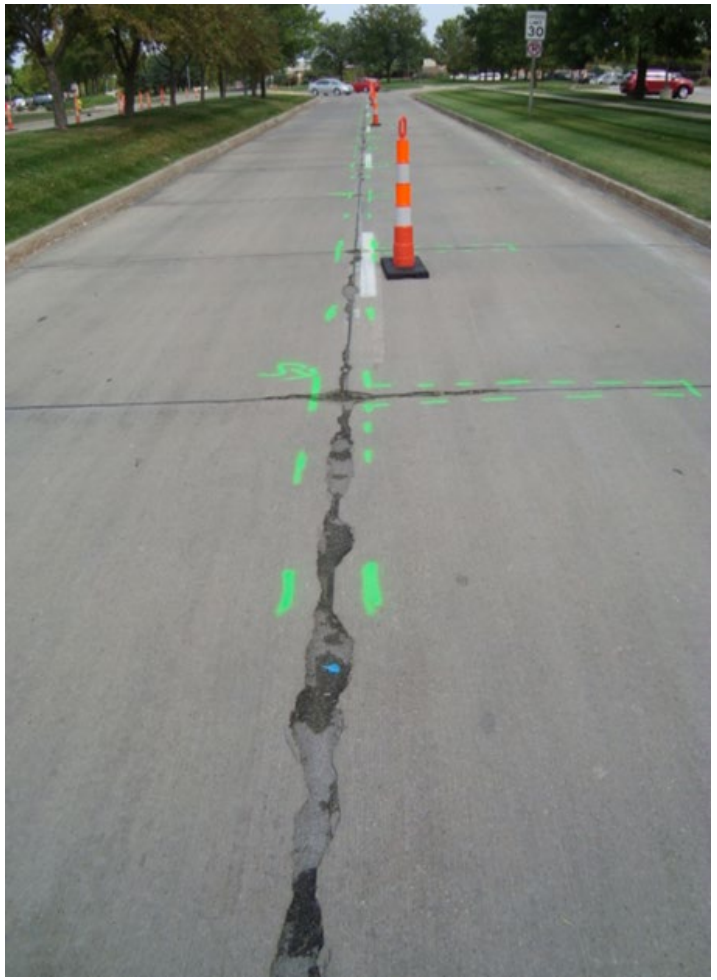
- Verify saw cut depth in the field!
  - If longitudinal joints are shallow, you may have time to re-saw
- Maintain blades and equipment
  - Select proper blade for aggregate type
  - Regularly check for wear and replace blades
  - Check the skid plate on early-entry saws



Durability

Joint Durability

- Moisture and chloride ingress play a role in many concrete deterioration mechanisms
- Joints are the most common location of early deterioration and premature failure in concrete pavements



Joint Deterioration Mechanisms

- Saturated freeze-thaw damage
  - Poor quality air void system
  - Highly permeable paste
- Durability cracking (D-cracking)
  - Unsuitable, porous aggregates
- De-icing salt attack
  - Greater use of $MgCl_2$, $CaCl_2$
  - Mixes not optimized for resistance
- Incompressible materials

Image: APTech

Preventing Joint Deterioration

- First things first: build good concrete pavements
  - Ensure sufficient drainage
  - Use a durable concrete mix with a good air void system
  - Follow best practices for sawing and filling joints

Durable Concrete Mixtures

- What do we need to target with our concrete mix?
  - Good air void system
  - Quality aggregates
  - Low w/cm (< 0.45 or lower)
  - SCMs (at least 20% replacement)

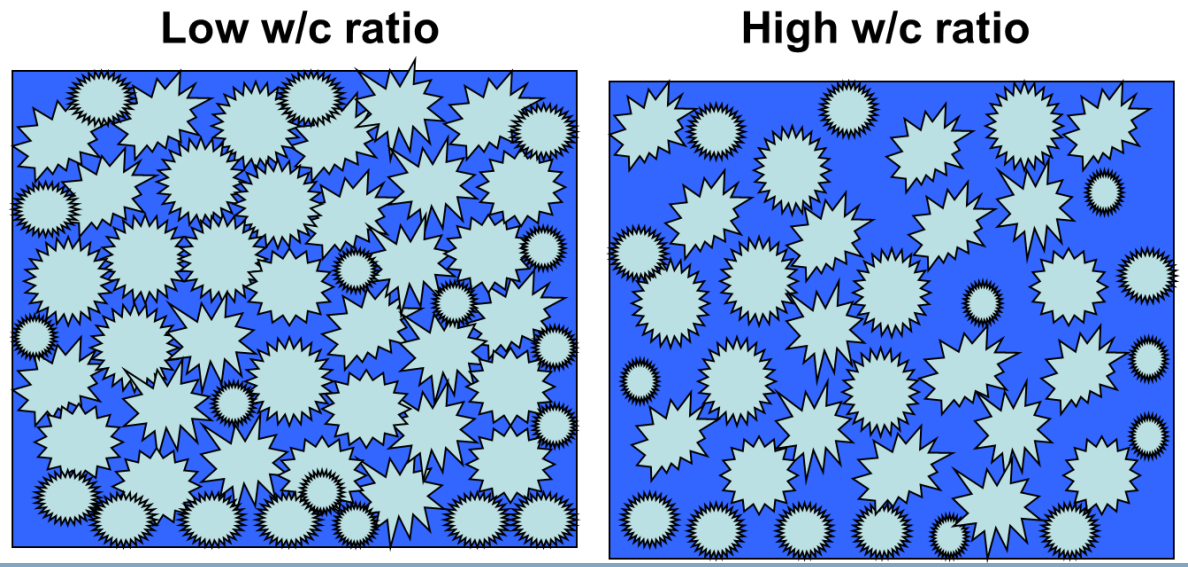
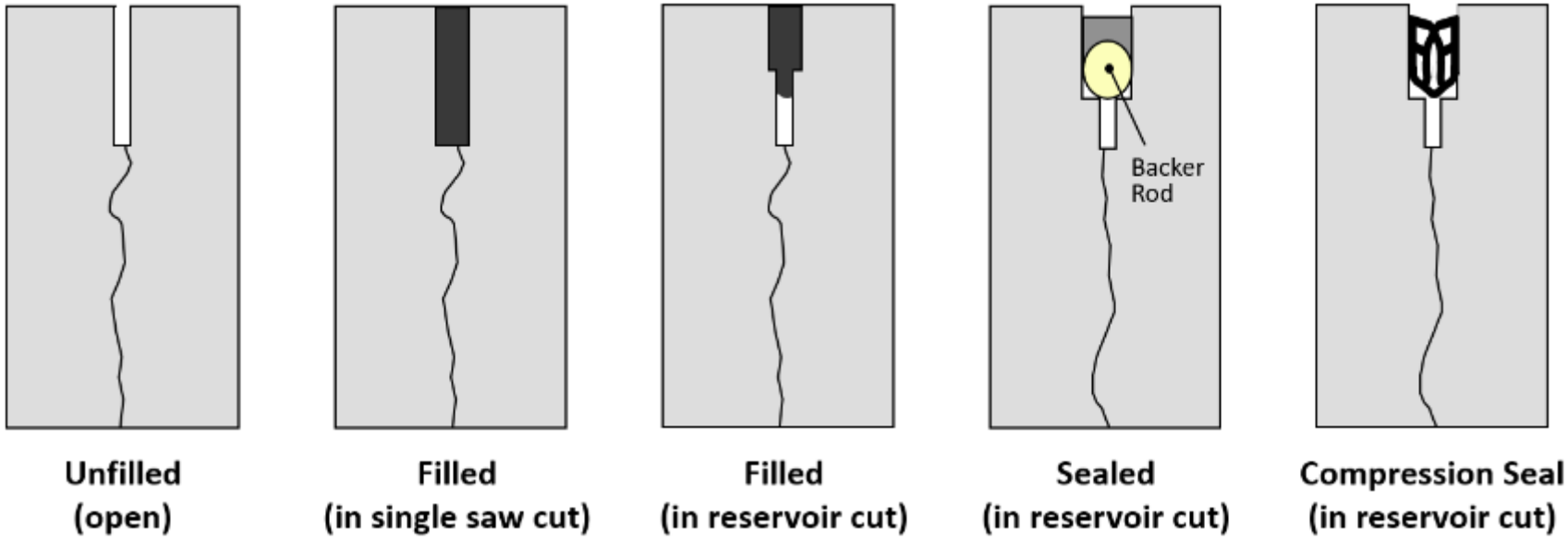


Image: Todd Hanson

Joint Sealing / Filling

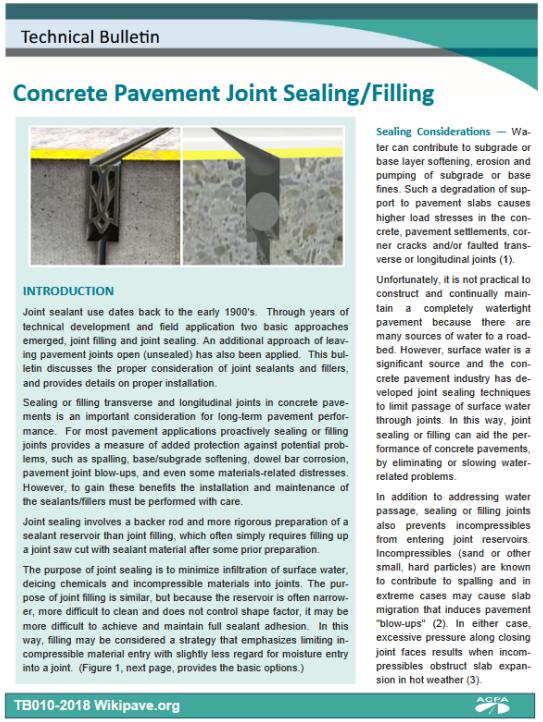
- Do we need to seal or fill our joints?
  - Sealing / filling helps keep fluids and incompressible materials out of the joint and out of the pavement system



Images: ACPA

Joint Sealing / Filling

- Should I always seal or fill joints? Are there situations where it is not necessary?
  - ACPA Technical Bulletin TB010-2018:



Technical Bulletin

Concrete Pavement Joint Sealing/Filling

INTRODUCTION

Joint sealant use dates back to the early 1900's. Through years of technical development and field application two basic approaches emerged, joint filling and joint sealing. An additional approach of leaving pavement joints open (unsealed) has also been applied. This bulletin discusses the proper consideration of joint sealants and fillers, and provides details on proper installation.

Sealing or filling transverse and longitudinal joints in concrete pavements is an important consideration for long-term pavement performance. For most pavement applications proactively sealing or filling joints provides a measure of added protection against potential problems, such as spalling, base/subgrade softening, dowel bar corrosion, pavement joint blow-ups, and even some materials-related distresses. However, to gain these benefits the installation and maintenance of the sealants/fillers must be performed with care.

Joint sealing involves a backer rod and more rigorous preparation of a sealant reservoir than joint filling, which often simply requires filling up a joint saw cut with sealant material after some prior preparation.

The purpose of joint sealing is to minimize infiltration of surface water, deicing chemicals and incompressible materials into joints. The purpose of joint filling is similar, but because the reservoir is often narrower, more difficult to clean and does not control shape factor, it may be more difficult to achieve and maintain full sealant adhesion. In this way, filling may be considered a strategy that emphasizes limiting incompressible material entry with slightly less regard for moisture entry into a joint. (Figure 1, next page, provides the basic options.)

Sealing Considerations — Water can contribute to subgrade or base layer softening, erosion and pumping of subgrade or base fines. Such a degradation of support to pavement slabs causes higher load stresses in the concrete, pavement settlements, corner cracks and/or faulted transverse or longitudinal joints (1).

Unfortunately, it is not practical to construct and continually maintain a completely watertight pavement because there are many sources of water to a roadbed. However, surface water is a significant source and the concrete pavement industry has developed joint sealing techniques to limit passage of surface water through joints. In this way, joint sealing or filling can aid the performance of concrete pavements, by eliminating or slowing water-related problems.

In addition to addressing water passage, sealing or filling joints also prevents incompressibles from entering joint reservoirs. Incompressibles (sand or other small, hard particles) are known to contribute to spalling and in extreme cases may cause slab migration that induces pavement "blow-ups" (2). In either case, excessive pressure along closing joint faces results when incompressibles obstruct slab expansion in hot weather (3).

TB010-2018 Wikipave.org

Joint Sealing / Filling

KEY:

NR=Not recommended

Should perform adequately based on engineering judgment and limited experience (if sealed/filled then also with correct installation/maintenance procedures)

Will perform adequately based on engineering judgment and limited experience (if sealed/filled then also with correct installation/maintenance procedures)

	STREETS / ROADS / HIGHWAYS							
	Any Posted Speed Limit (Unless Indicated by Note)							
Layer Below Slab	Dense-Graded Base or Subgrade Soil				Non-Erodible (2) or Free-Draining Layer (3)			
Climatic Zone	Dry No-Freeze		Other		Dry No-Freeze		Other	
Joint Spacing	≤ 6 ft (2 m)	> 6 ft (2 m)	≤ 6 ft (2 m)	> 6 ft (2 m)	≤ 6 ft (2 m)	> 6 ft (2 m)	≤ 6 ft (2 m)	> 6 ft (2 m)
Open Reservoir Cut	NR	NR	NR	NR	NR	NR	NR	NR
Open Narrow Saw Cut	■	■	■	NR	■	■	■ (4,5)	■ (5)
Filled Saw Cut or Reservoir	■	■	■ (6)	■ (6)	■	■	■ (6)	■ (6)
Sealed Saw Cut or Reservoir	■	■	■	■	■	■	■	■

[4]Sealing recommended in freezing climates

[5]Sealing recommended when speed limit <45 mph

Penetrating Surface Sealers

- May be used to reduce the permeability of concrete at the surface or at the joints
- Provide additional protection from water and de-icing chemicals
- Enhance the performance of good concrete in challenging environments
- Improve existing pavements that may be susceptible to joint deterioration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Back to Basics – Jointing 101

Design & Layout

2026 Tech Tuesday

Webinar Series

April 14, 2026

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American Concrete Pavement Association

ACPA

AMERICAN CONCRETE
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Joint Design & Layout

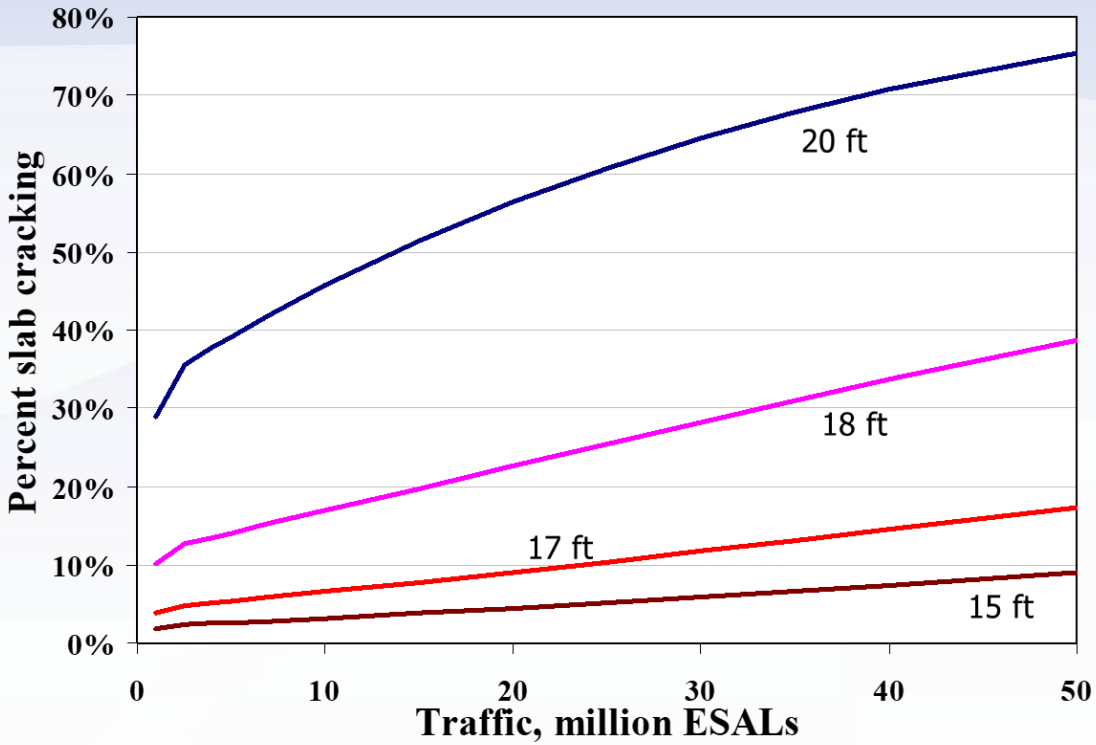
Designing a Joint Layout for Complex Geometries

Joint Layout “Best Practices” Summary

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

Joint Spacing

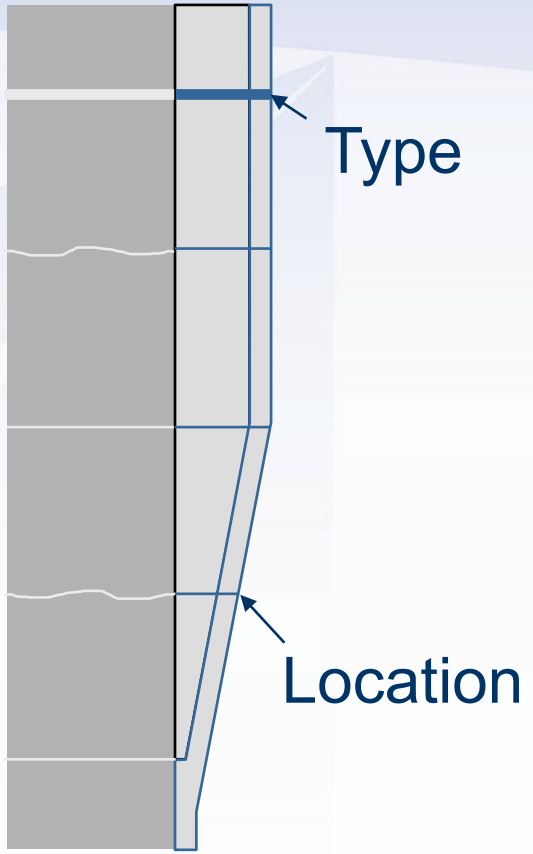
- Keep slabs square or rectangular
  - Do not exceed an aspect ratio of 1.5:1 (1.25:1 is ideal)
- Longitudinal joints may not match lane lines
- Slabs should not exceed 15 ft
  - Larger slabs = larger stresses
  - Determine a max joint spacing based on scenario
  - Calculator: http://www.apps.acpa.org/apps/MaxJointSpacing.aspx



Basic Rules for Intersection Joint Layout

Things to Ensure:

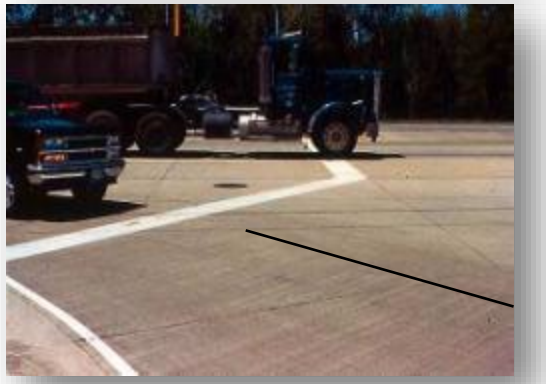
- Match existing joints or cracks – location AND type!
- Place joints to meet in-pavement structures
- Place isolation joints where needed
- Be practical in applying maximum joint spacing
- Prepare plan for jointing before paving
- **Allow for practical adjustments in the field!**



Basic Rules for Intersection Joint Layout

Things to Avoid:

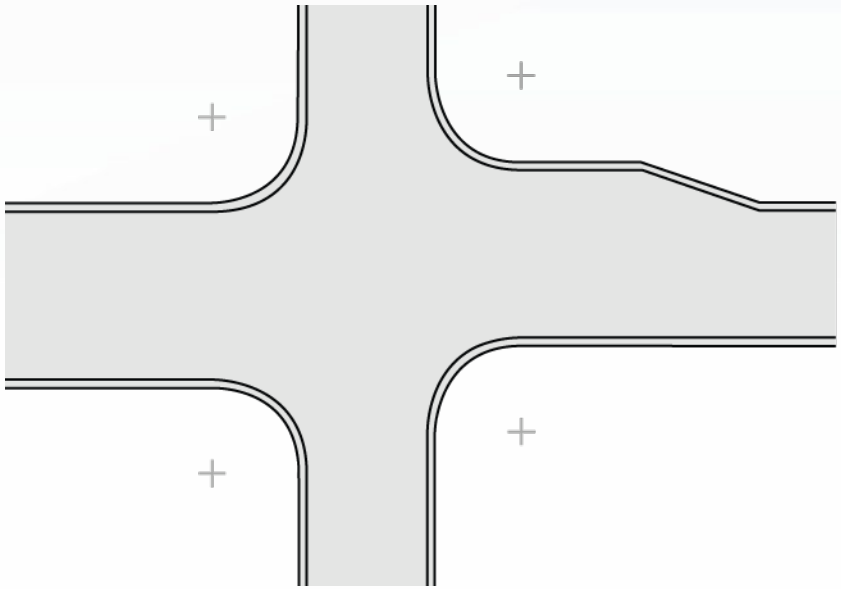
- Slabs < 2 ft wide
- Slabs > 15 ft wide
- Angles > 60º (90º is best)
  - Use “dog-leg” joints through curve radius points
- Creating interior corners
- “Odd” shapes (keep slabs square or rectangular, when possible)

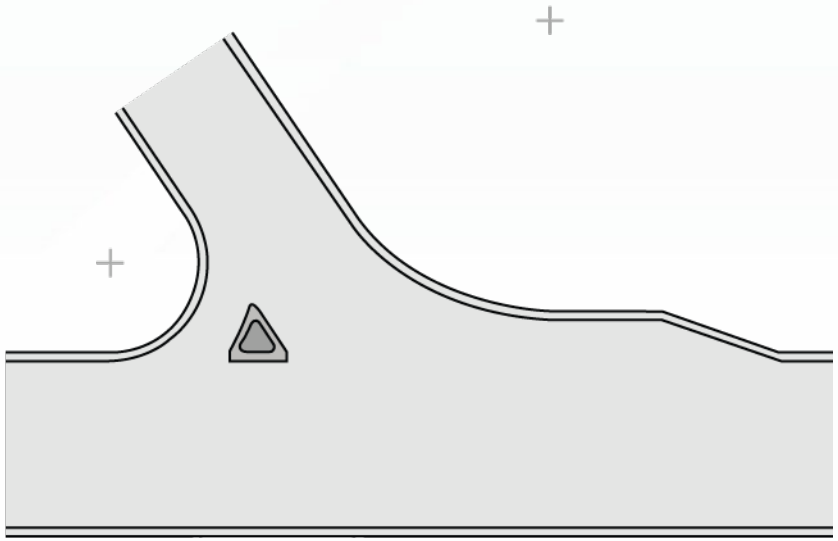


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

Step 1: Draw all pavement edge and back-of-curb lines to scale in the plan view.

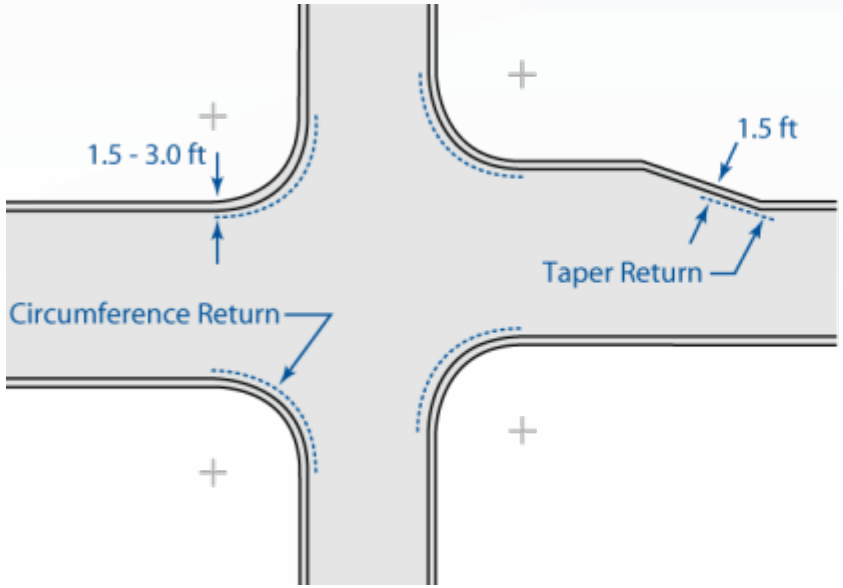


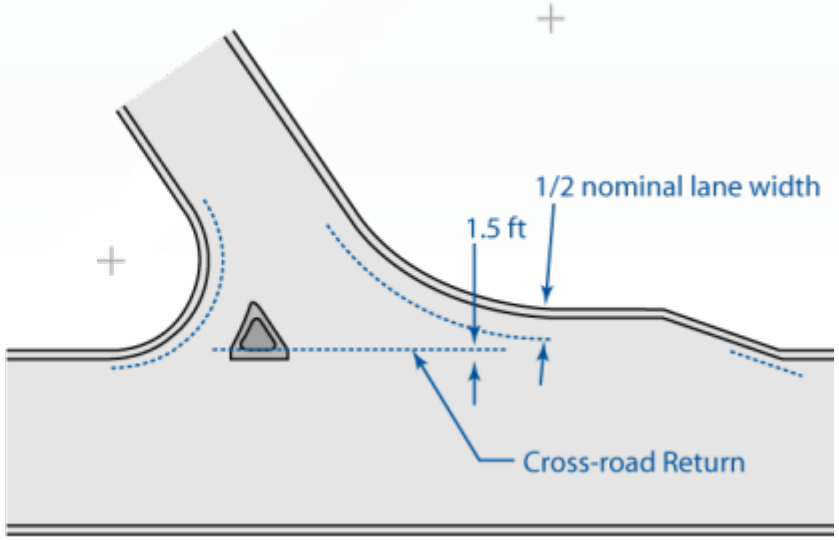


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

Step 2: Lightly draw circumference-return, taper-return, and crossroad-return lines as offsets of 1.5 – 3.0 ft

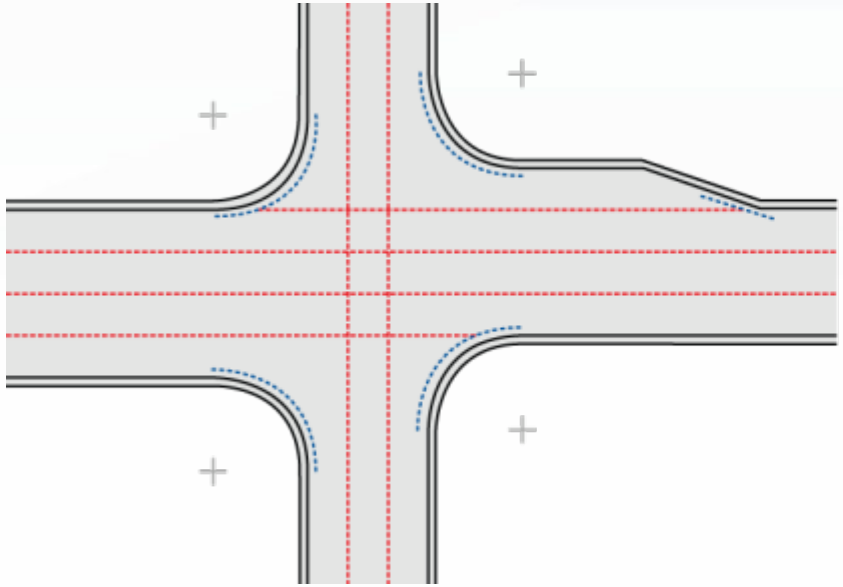


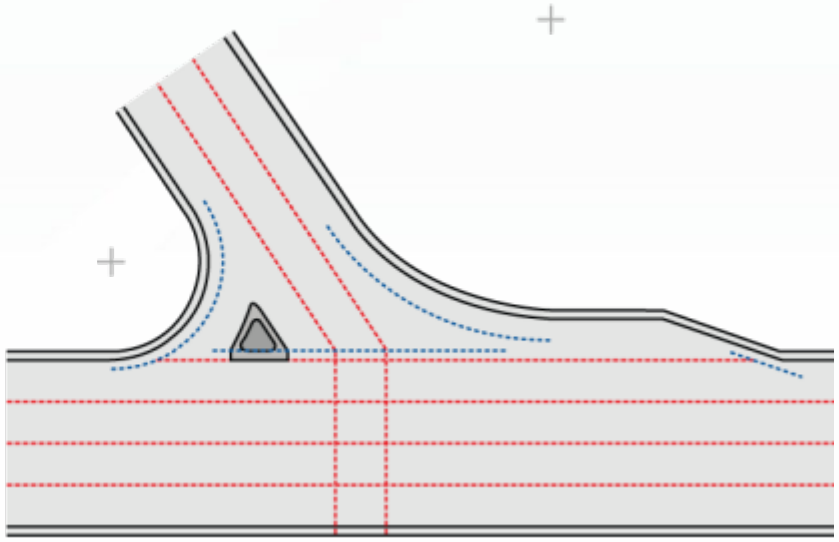


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

Step 3: Draw all lane lines on the mainline roadway and crossroad. Do not extend through return lines (offsets).

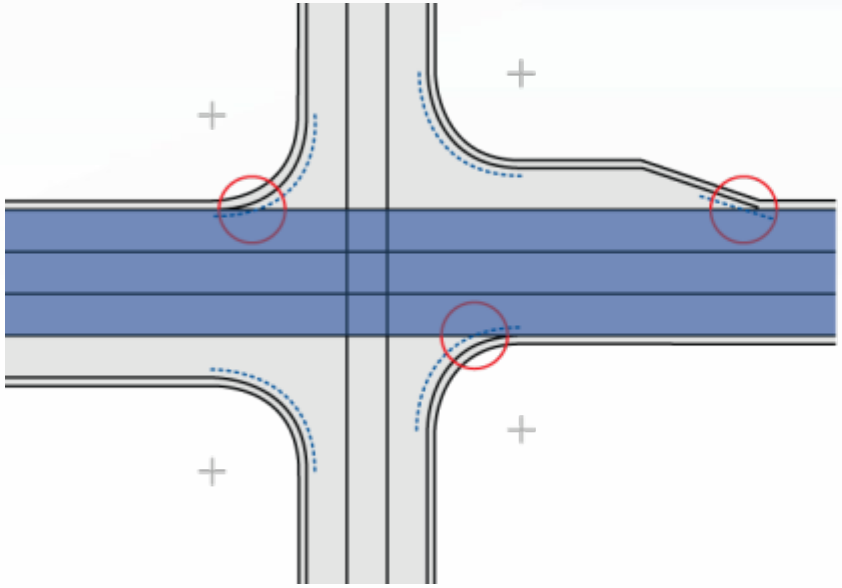


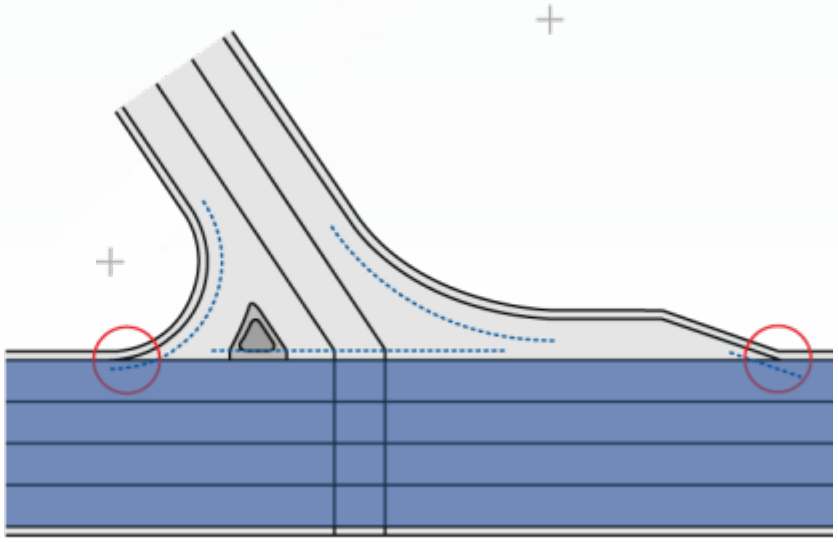


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

Step 4: Define mainline lanes for paving. Extend *only* these lane lines through return lines (offsets) to allow for slipform paving. Blockouts & doglegs will occur in the gutter pan at these locations.

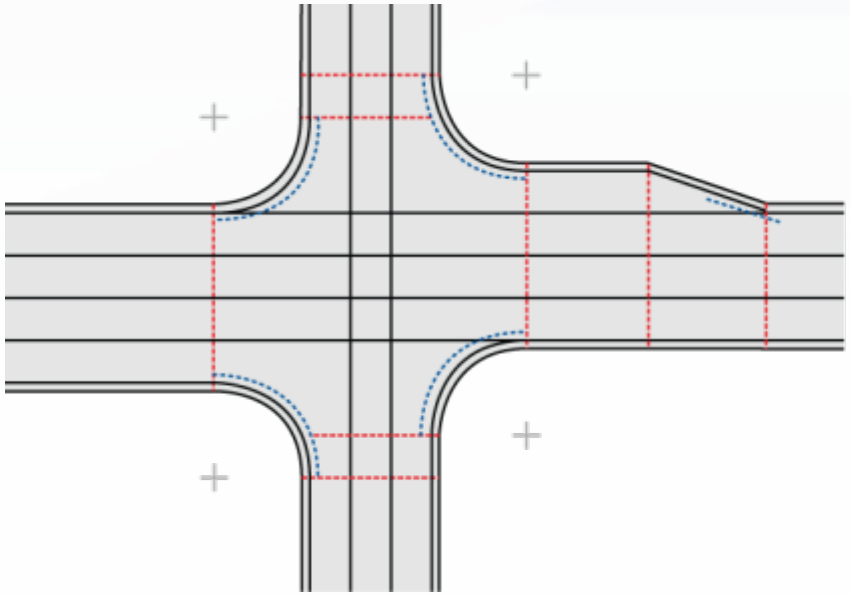


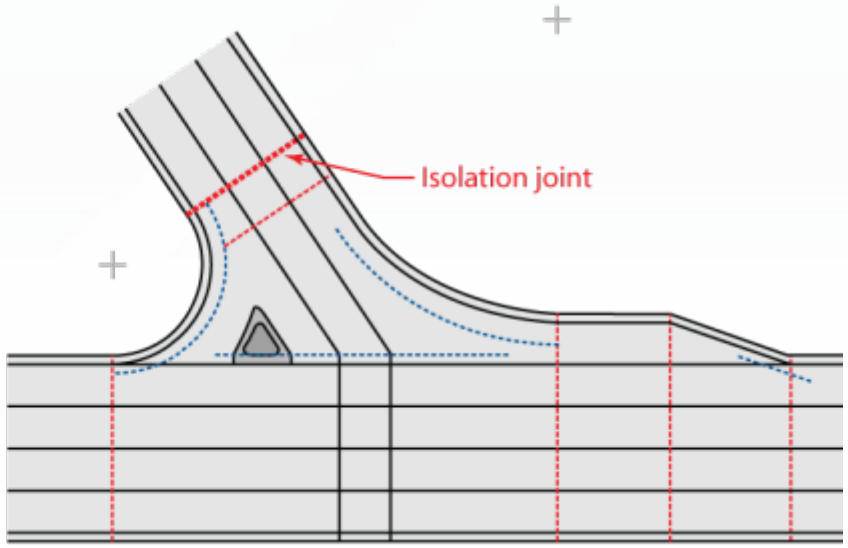


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

Step 5: Add transverse joints locations where a width change occurs in the pavement (begin & end of tapers, tangents, curves, curb returns, etc.) and extend these joints through the curb & gutter.

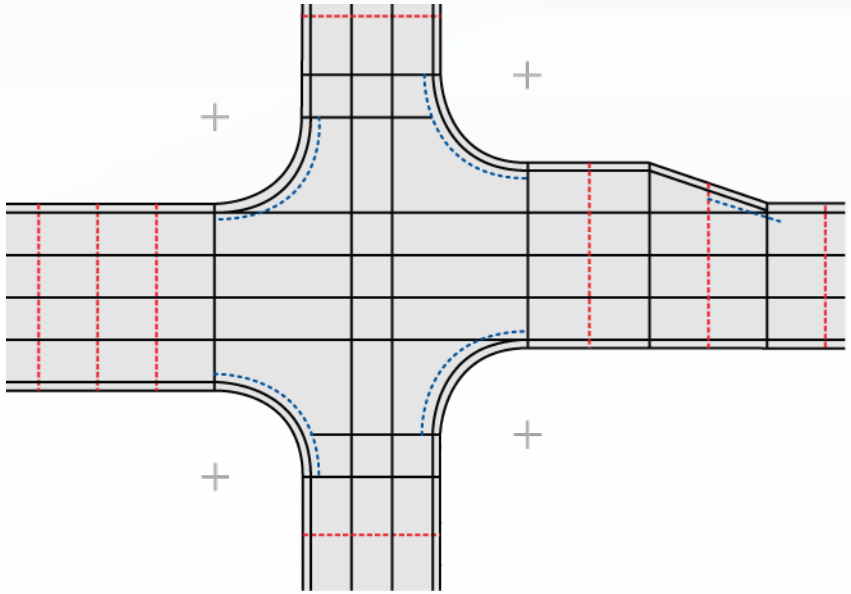


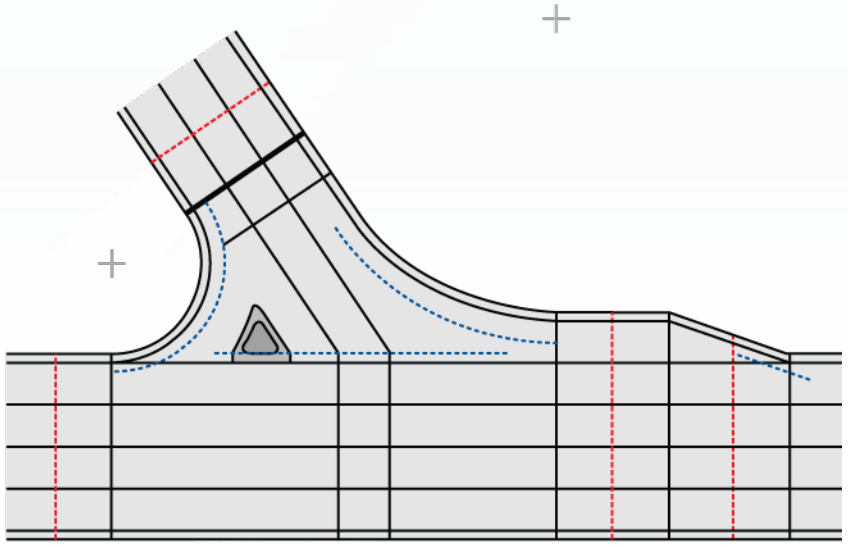


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

Step 6: Add transverse joints between and beyond the joints defined in Step 5, but not to the center of the intersection. Attempt to keep the distance between joints less than L_{max}.

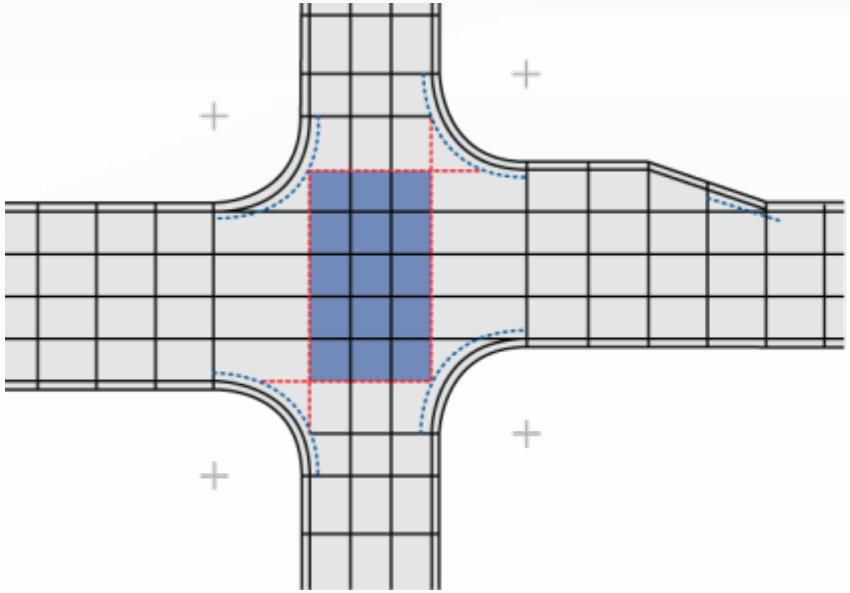


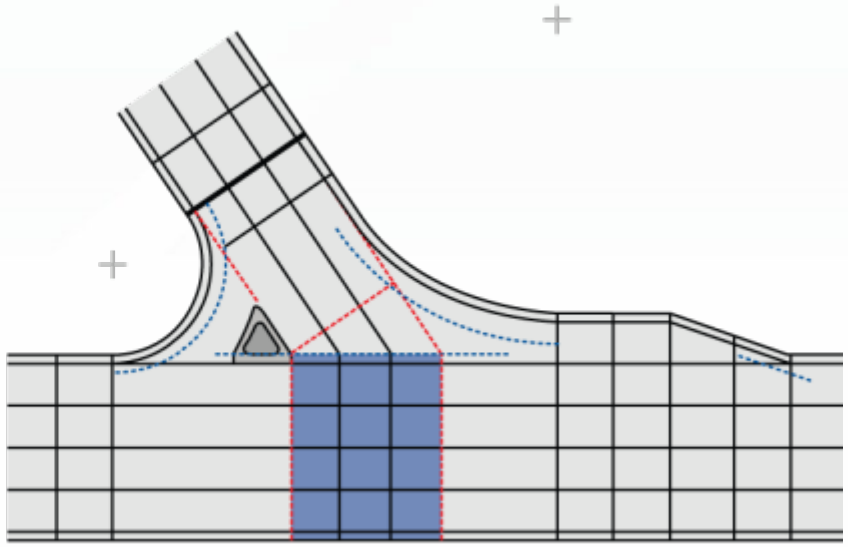


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

Step 7: Define the intersection box by extending the edges of pavement lines for the cross road and any turning lanes.

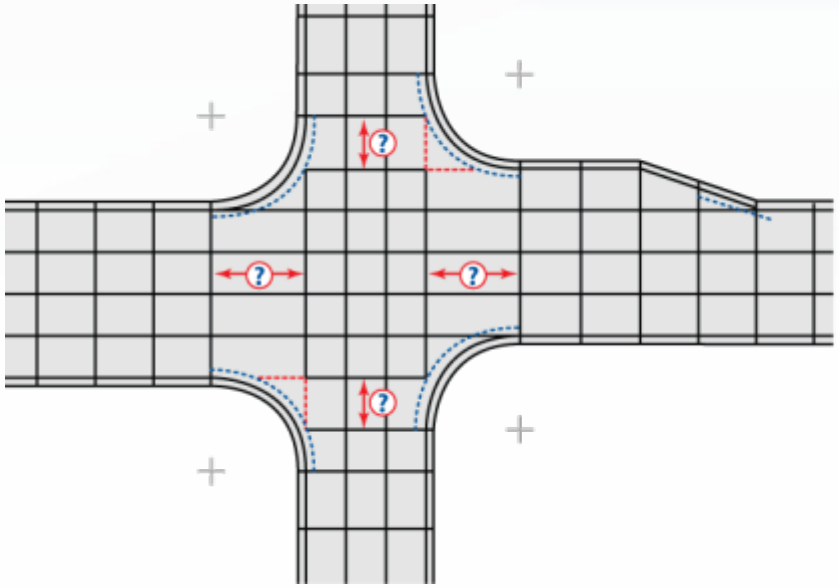


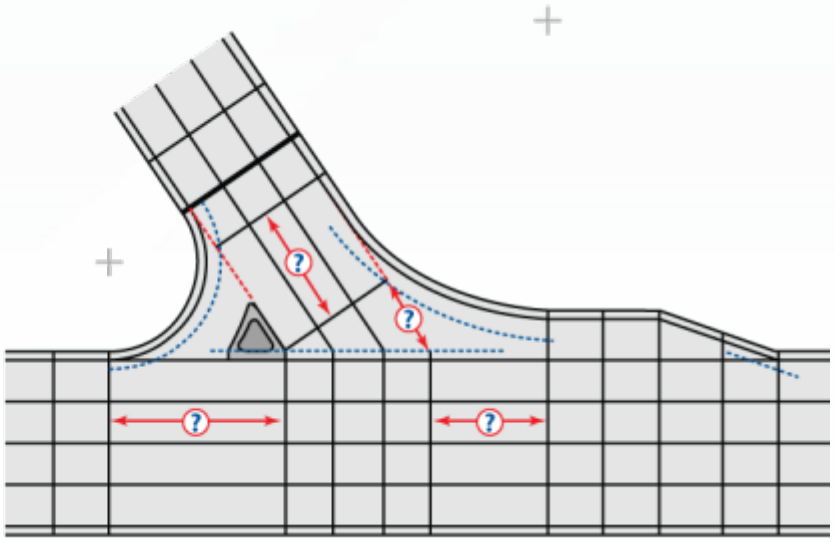


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

Step 8: Check the distances between the "intersection box" and the surrounding joints.

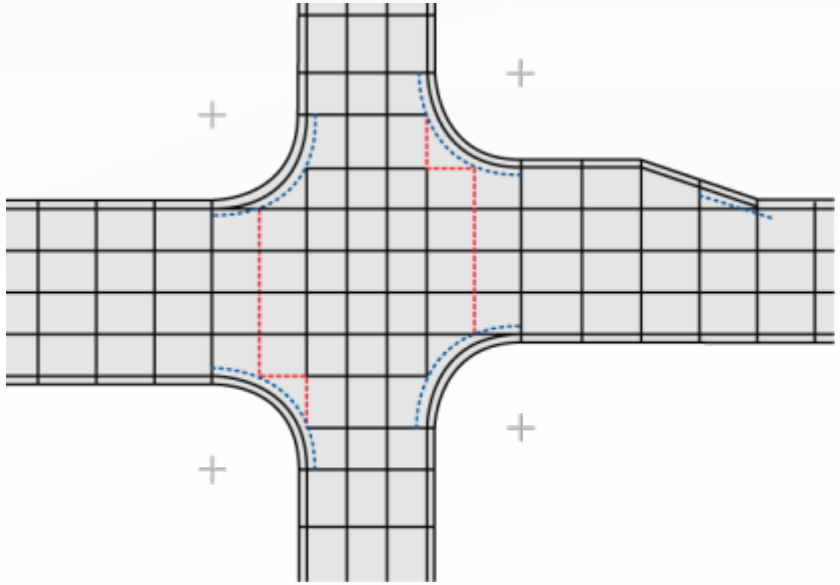


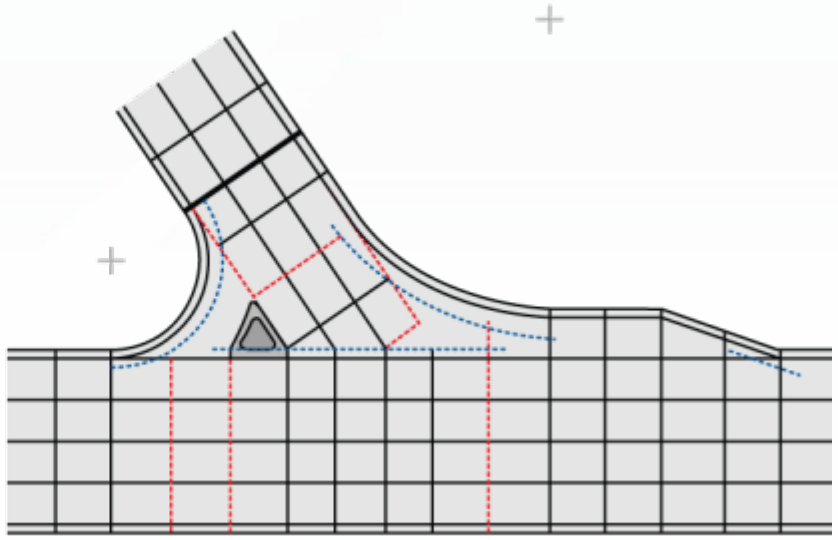


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

Step 9: If the distance is more than the maximum desirable joint spacing, add transverse joints at an equal spacing. Do not extend these joints through return lines.

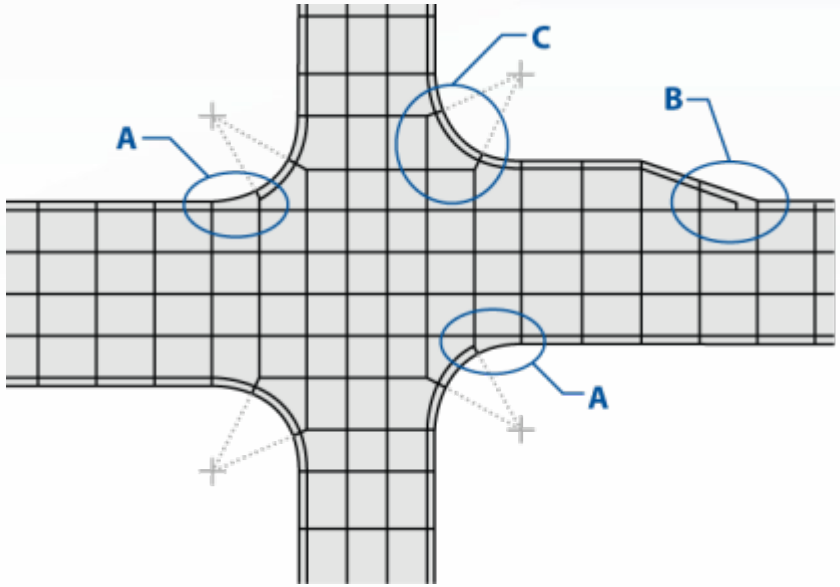


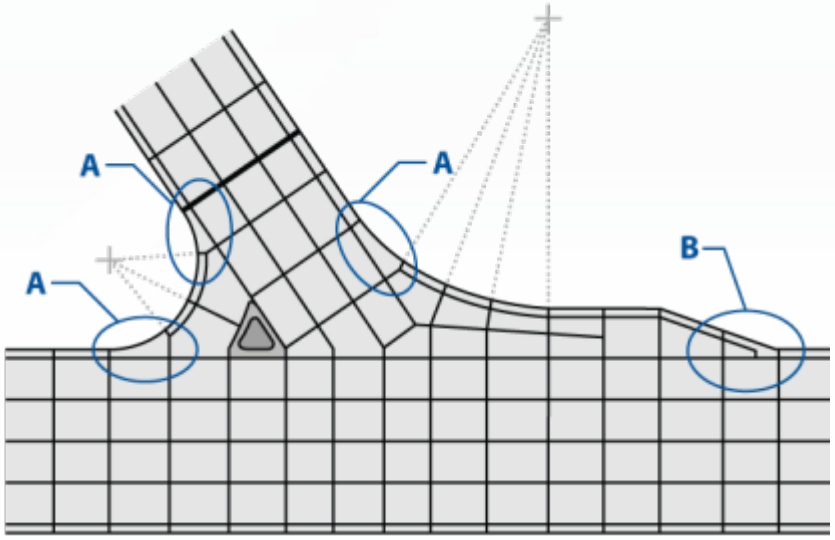


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

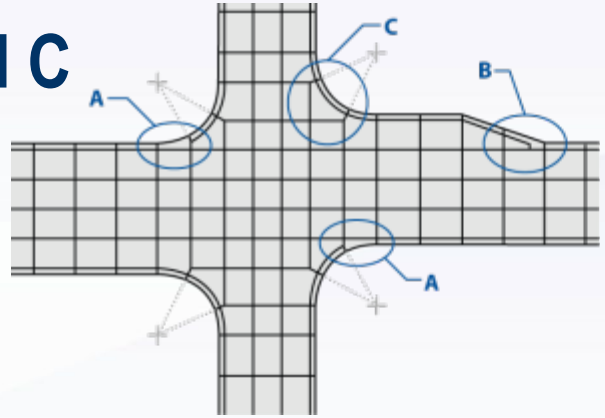
Step 10: Extend lines from center of curb return radii to corners of intersection box panels. Draw joints along these “diagonal” lines. Make adjustments to eliminate doglegs in pavement edges.

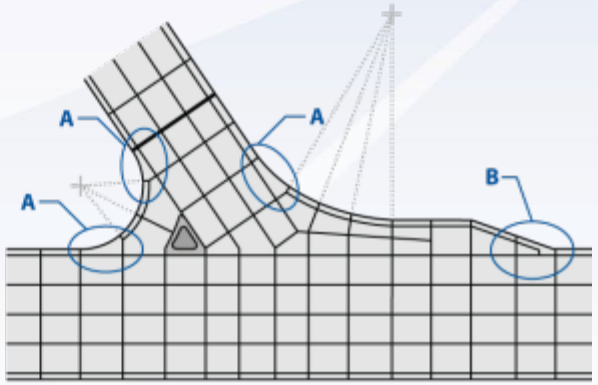


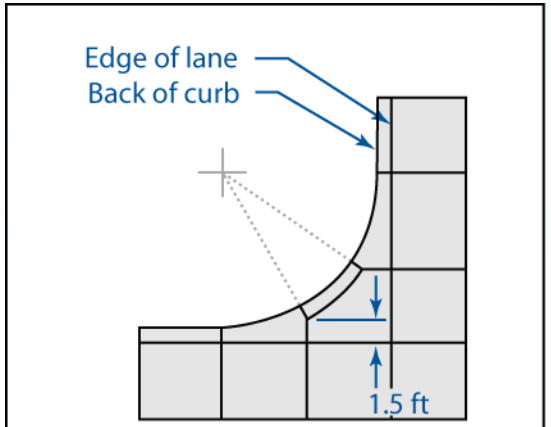


Concrete Intersections: Jointing

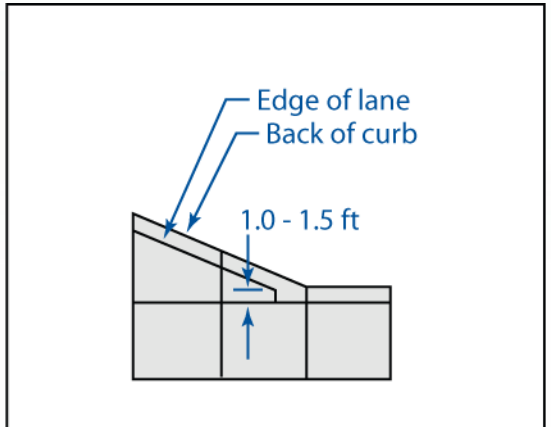
Details A, B, and C



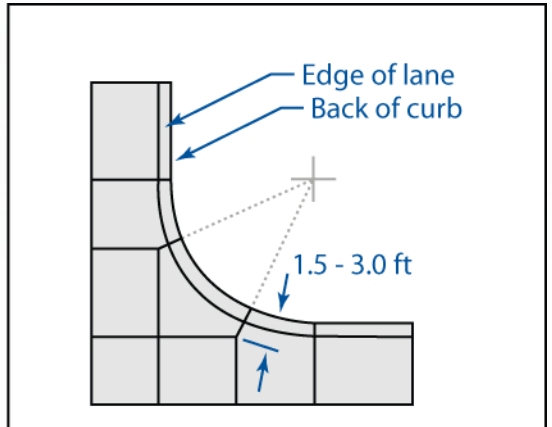




A Width change and dogleg in gutter near point of curvature

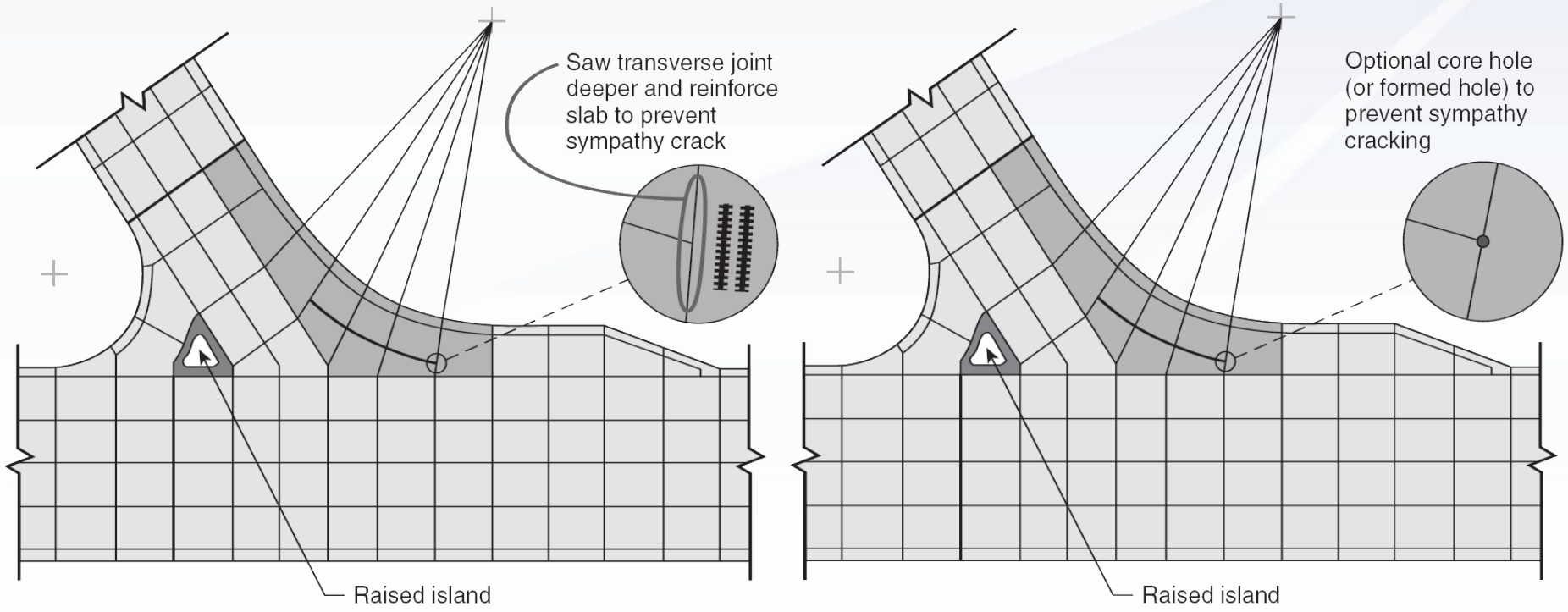


B Width change and dogleg in gutter near start of a taper



C Width change and dogleg in paving lane for hand-pours

Handling a Dead-end a Joint...

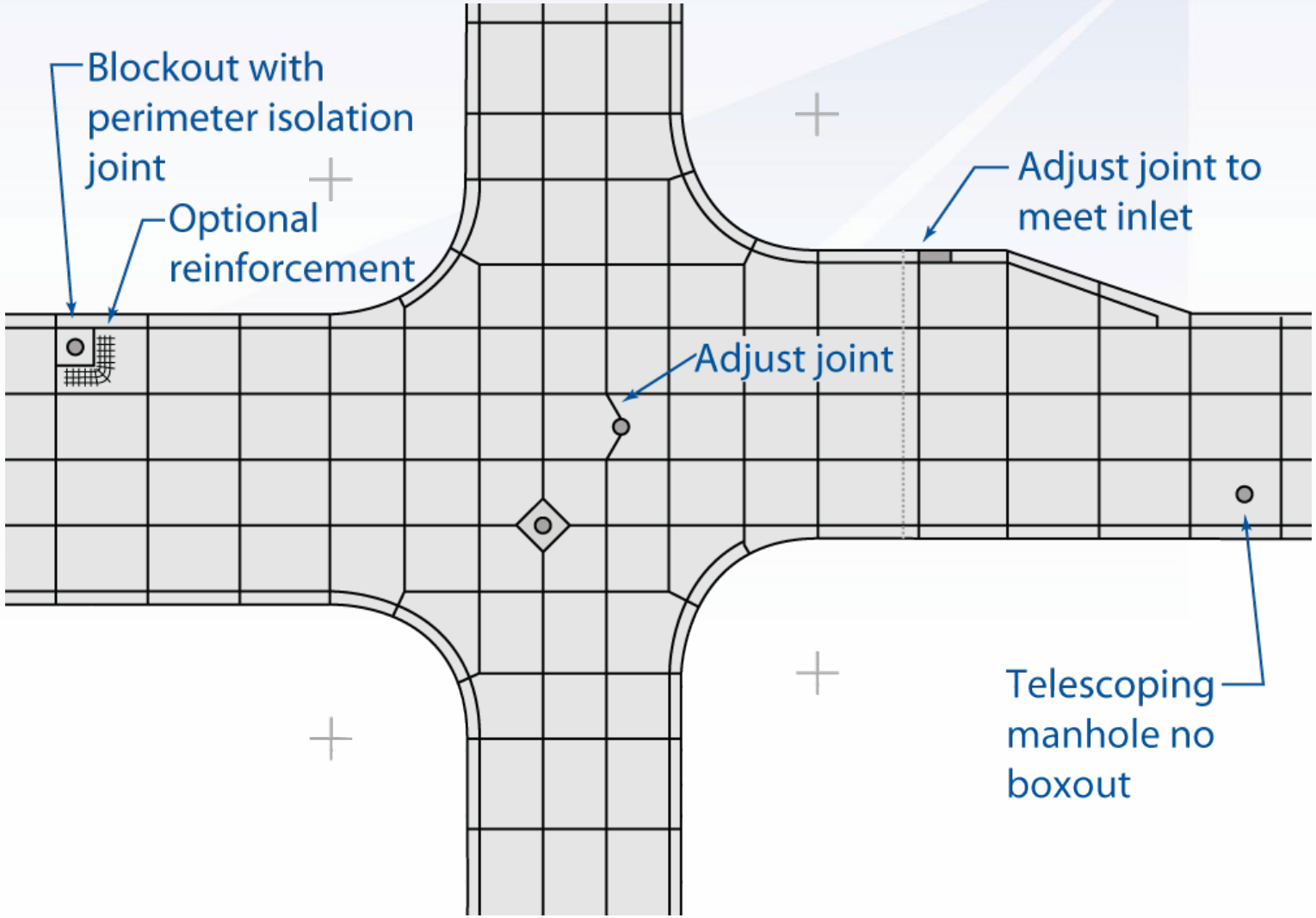


Handling a Dead-end a Joint...

Handling a Dead-end a Joint...

Field Adjustments

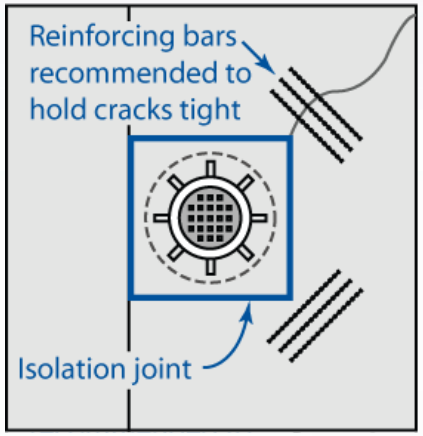
Adjust joints that are within 5 ft of a utility!



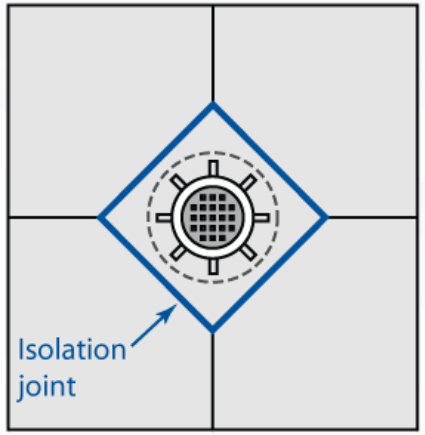
Concrete Intersections: Jointing

Box Out Fixture Details

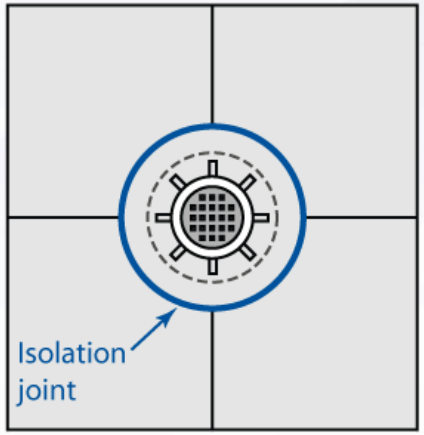
Square Manhole Boxout



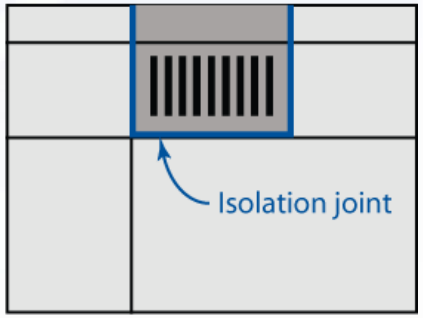
Diagonal Manhole Boxout



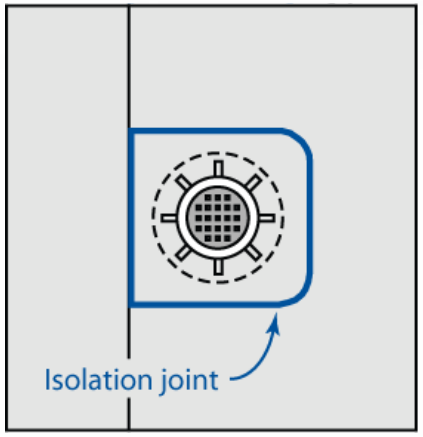
Circular Manhole Boxout



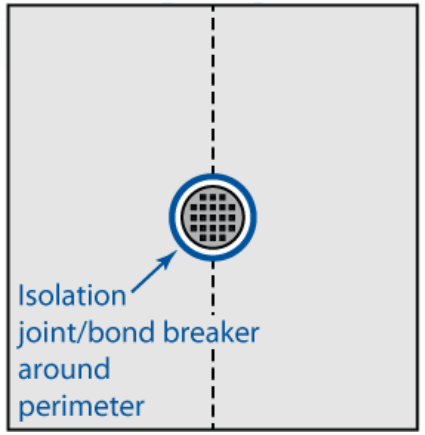
Square Inlet (no boxout)



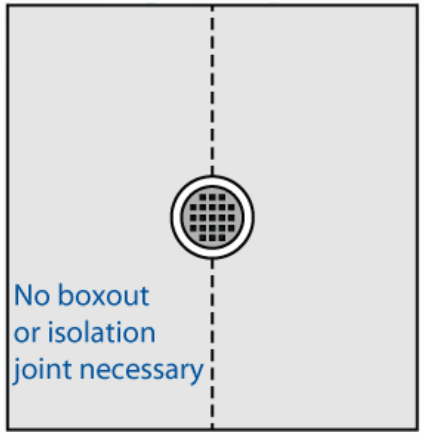
Square Boxout with Fillets



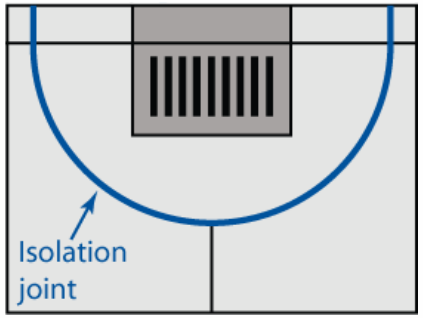
Manhole (No Boxout)



Telescoping Manhole



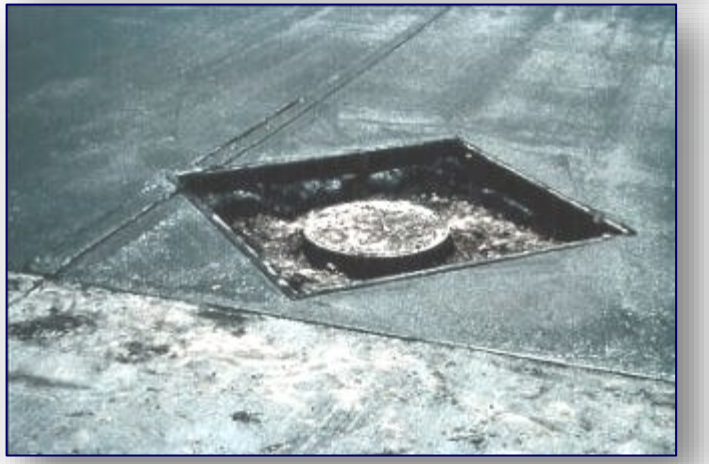
Round Inlet Boxout




Genesis Center
POOL&SPA
59 WEST

If You DO Box Out Properly…Good Results Happen!

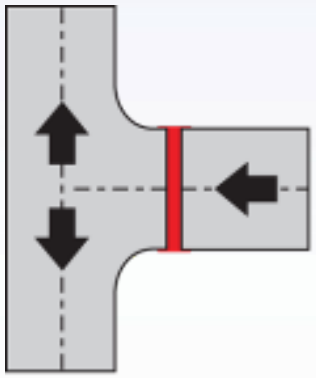
If You DON'T Box Out Properly...Bad Things Happen!



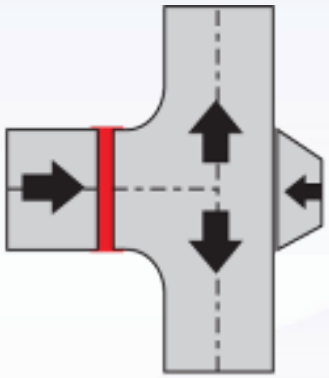
Manholes…

Images: CPAM

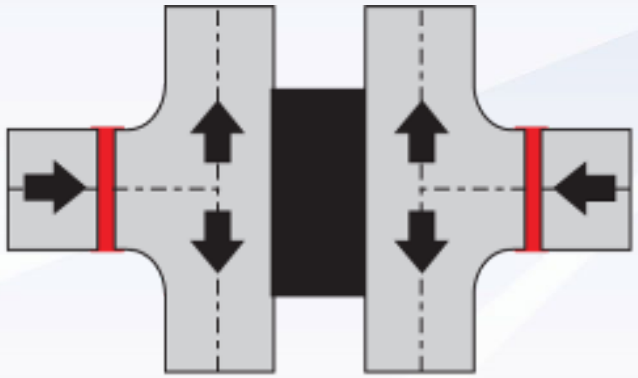
Where to Place Isolation Joints...



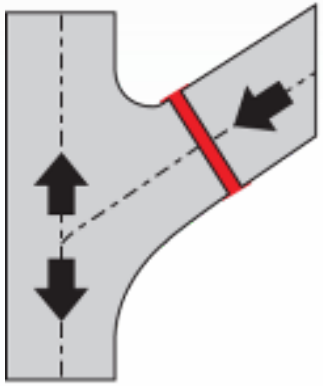
90° T



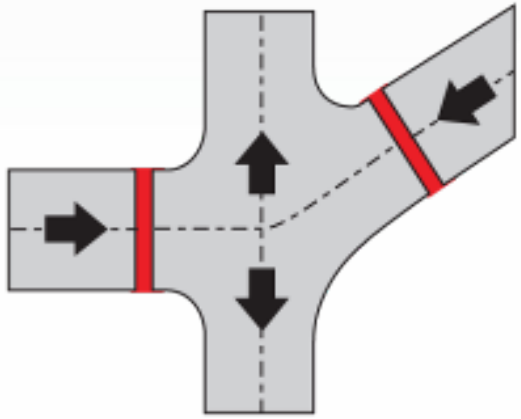
90° T/Apron



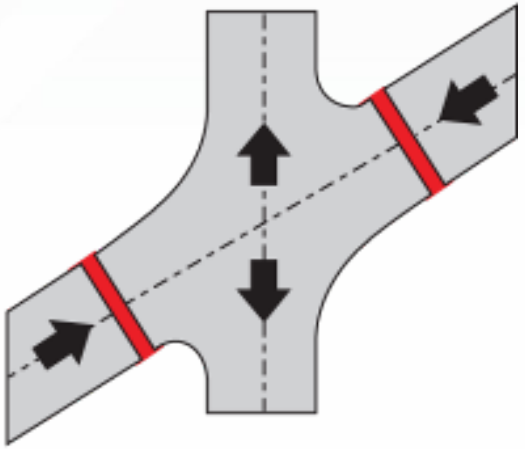
Divided highway
(non-concrte median)



Skewed T

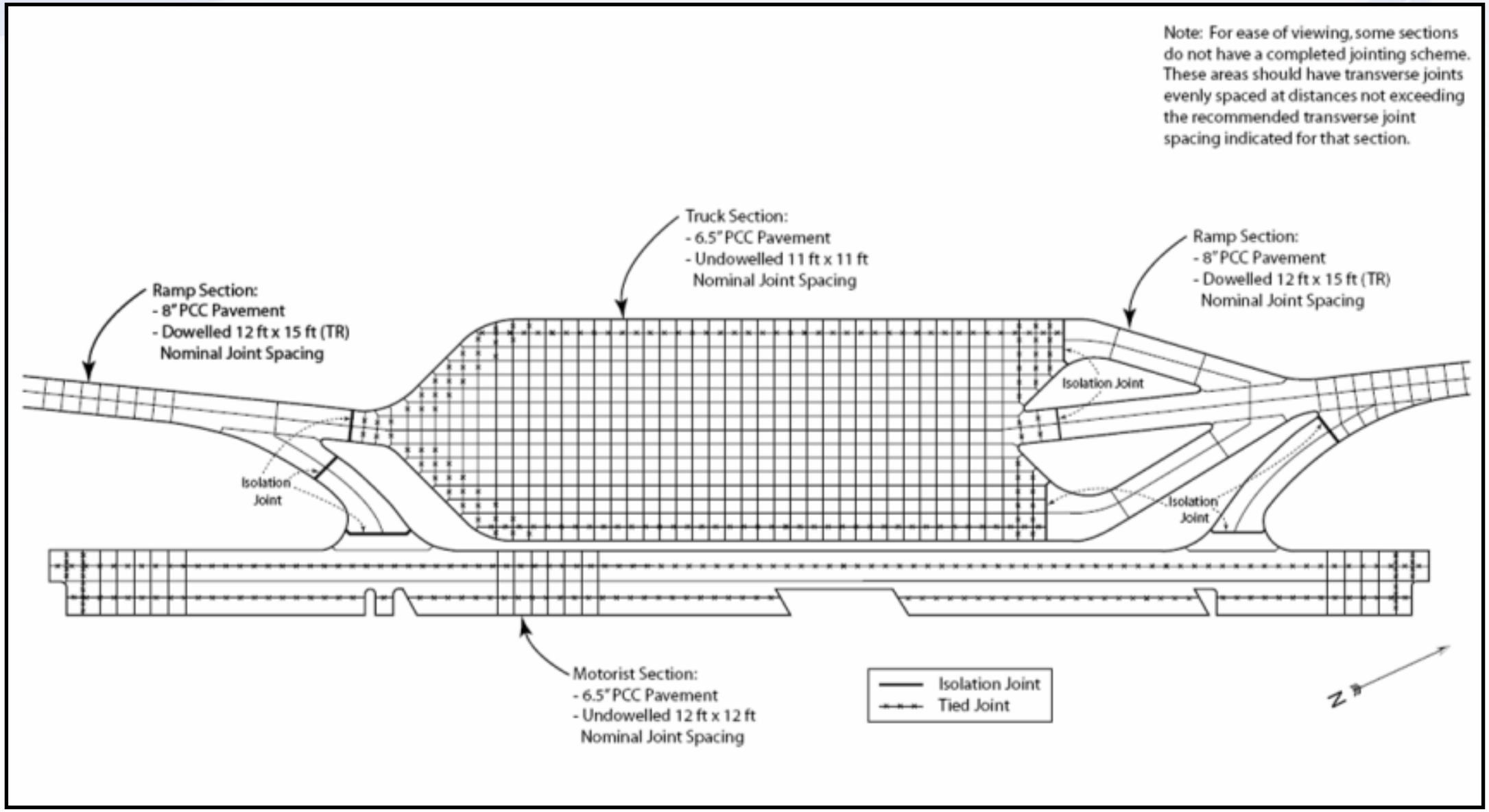


90° Skew



Skew/Skew

Method Works for Other Pavement Areas Too...



Parking Lot Joint Layout

- ACI 330 Guide for Design of Concrete Parking Lots
- Features:
  - Isolate from buildings, planters, sidewalks
  - Tension ring around the outside with tie bars (unless there is curb)
  - Avoid acute angles
  - Dowels in areas with consistent one-way traffic

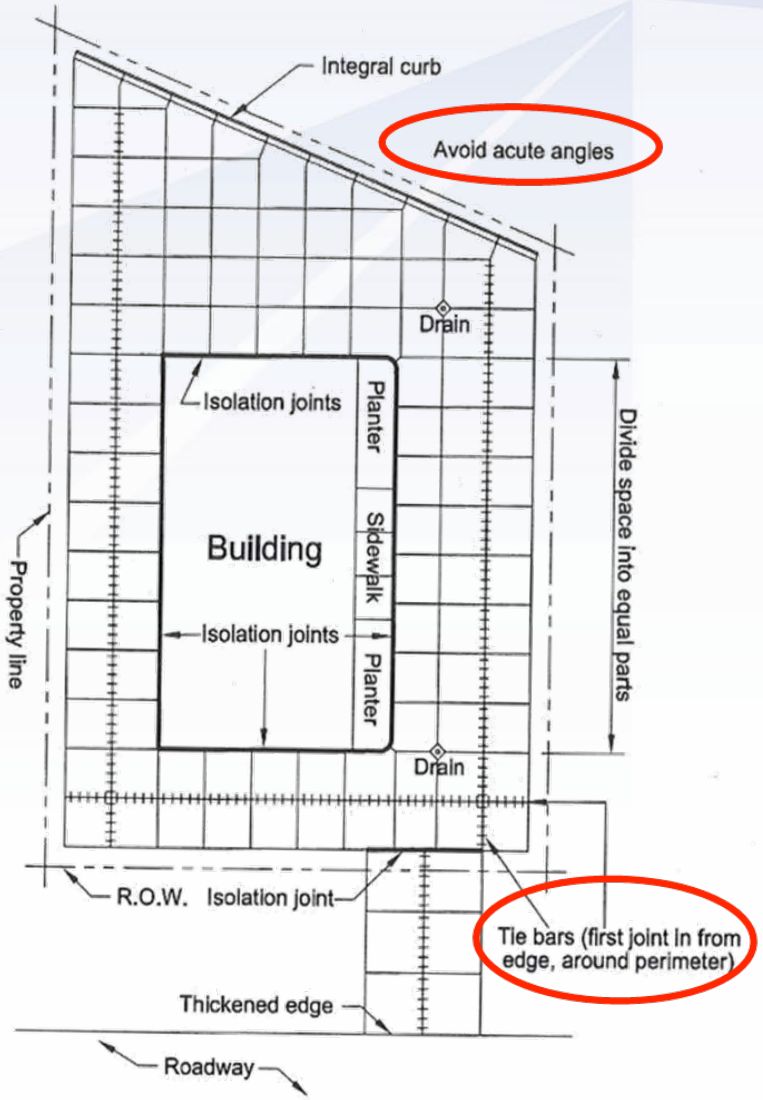


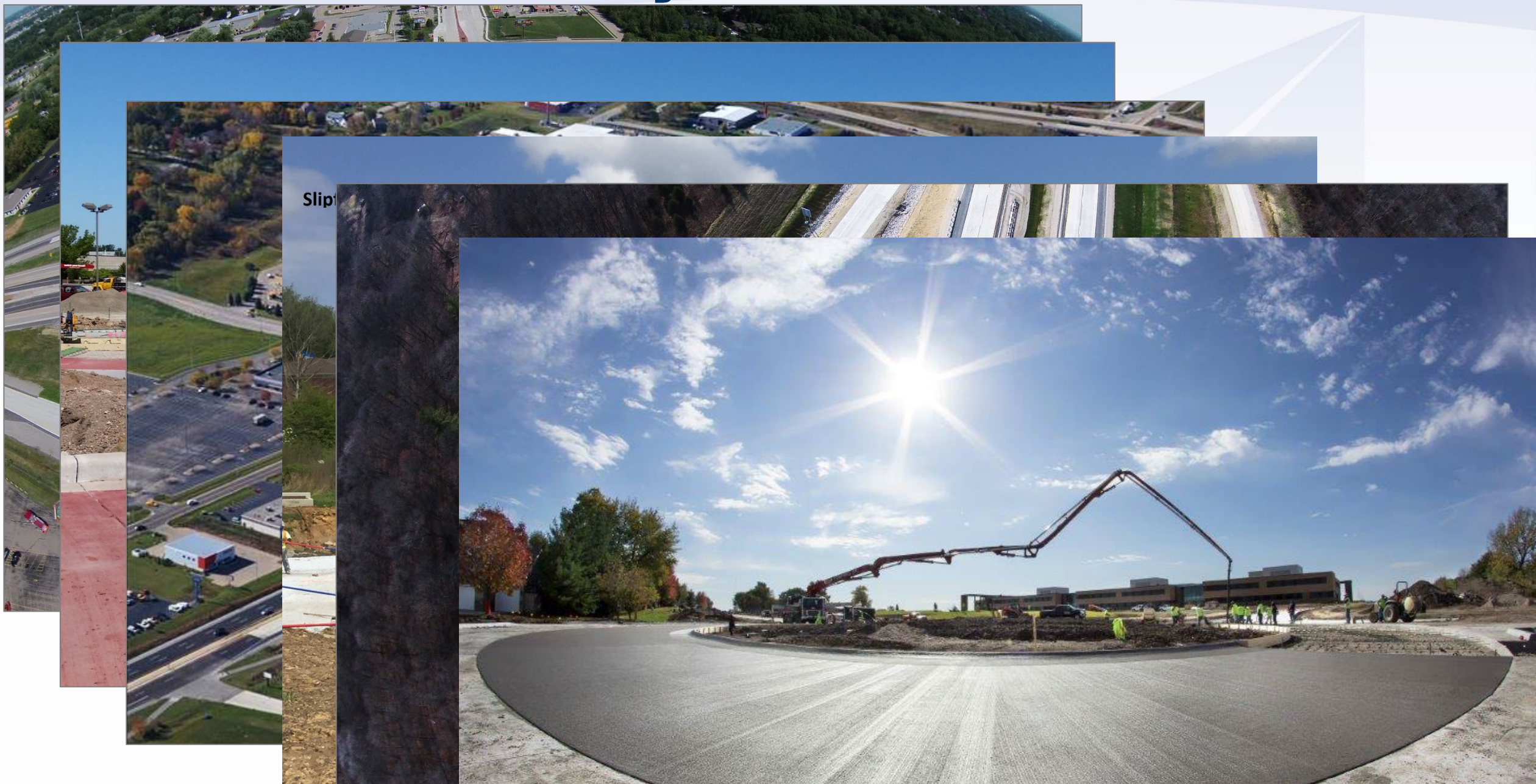
Image: ACI

Similar Methods Work for Other Pavement Areas Too…

Roundabouts

Interchanges

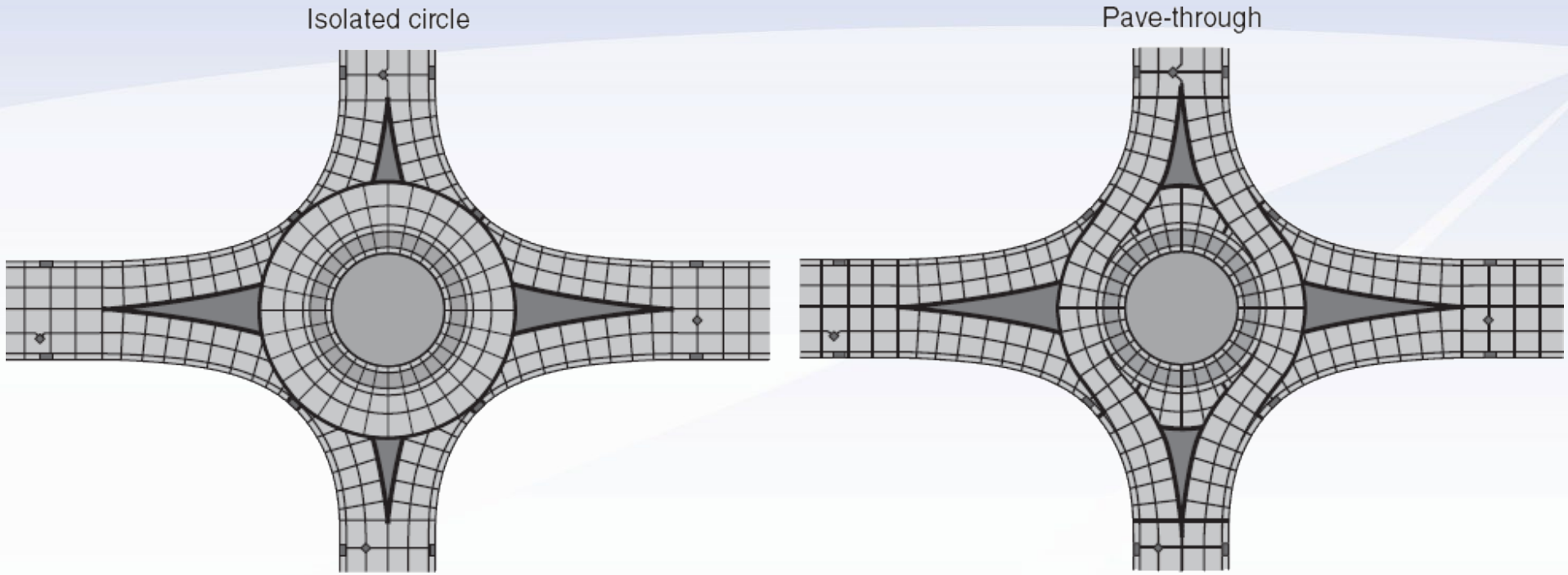
Concrete Pavement Versatility



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)



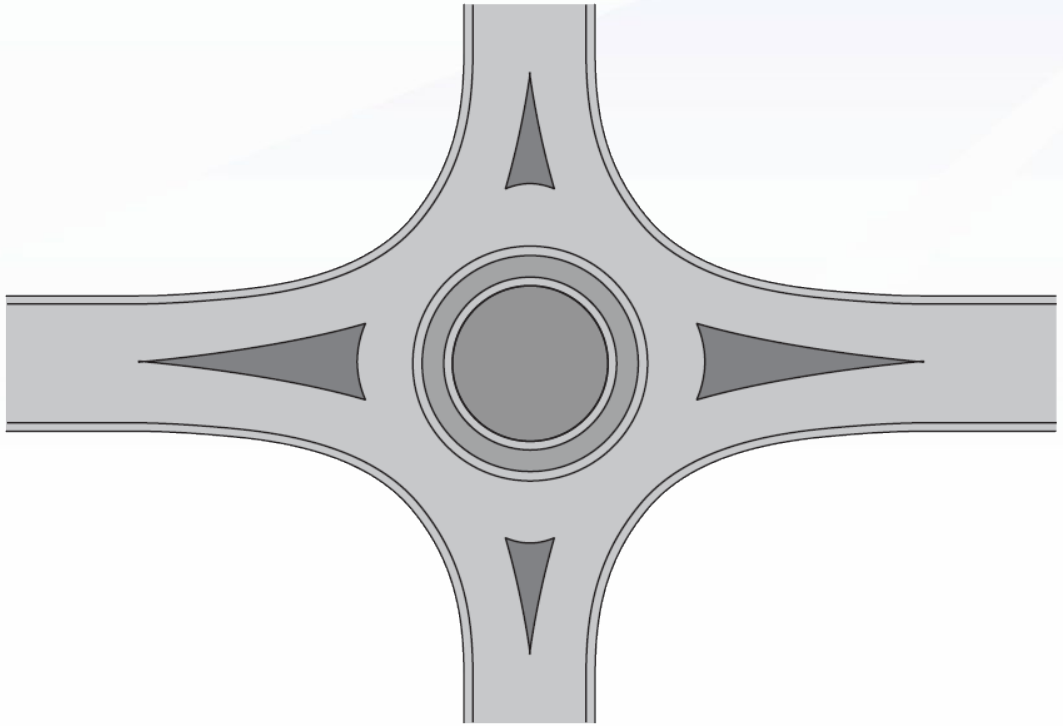
Concrete Roundabout Design And Construction

6-STEP METHOD FOR JOINTING ROUNDABOUTS

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

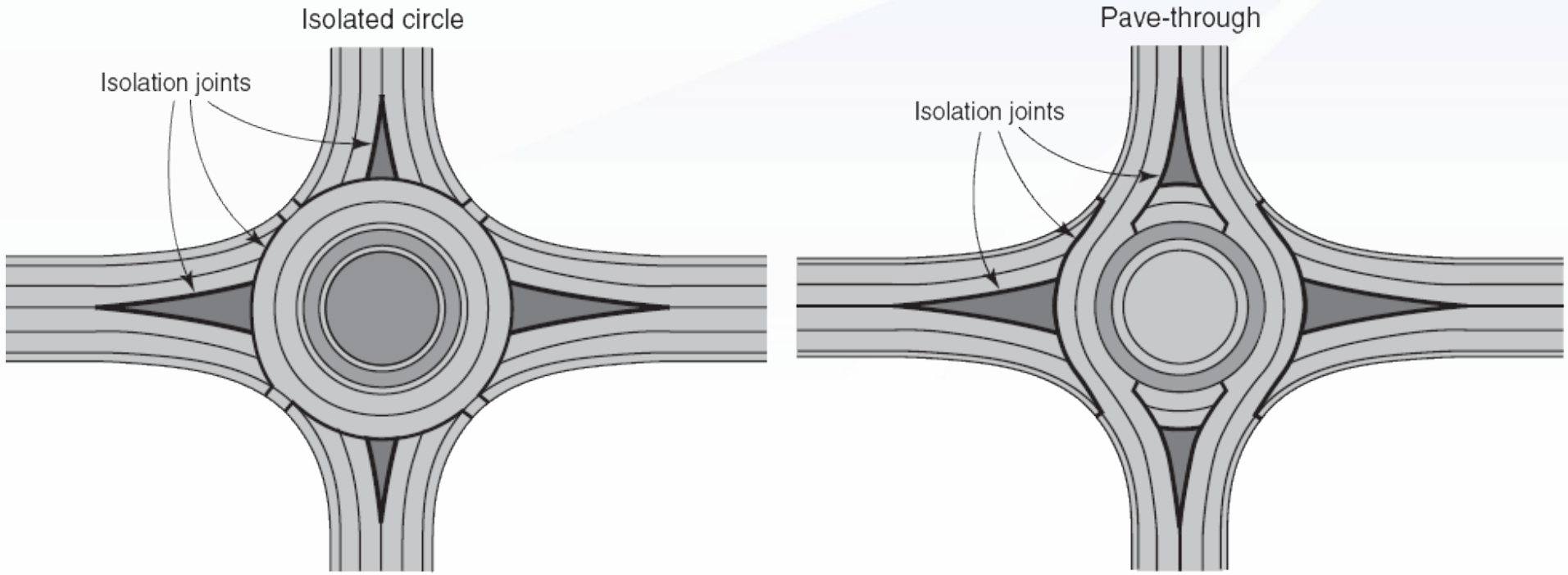
Jointing a Roundabout

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



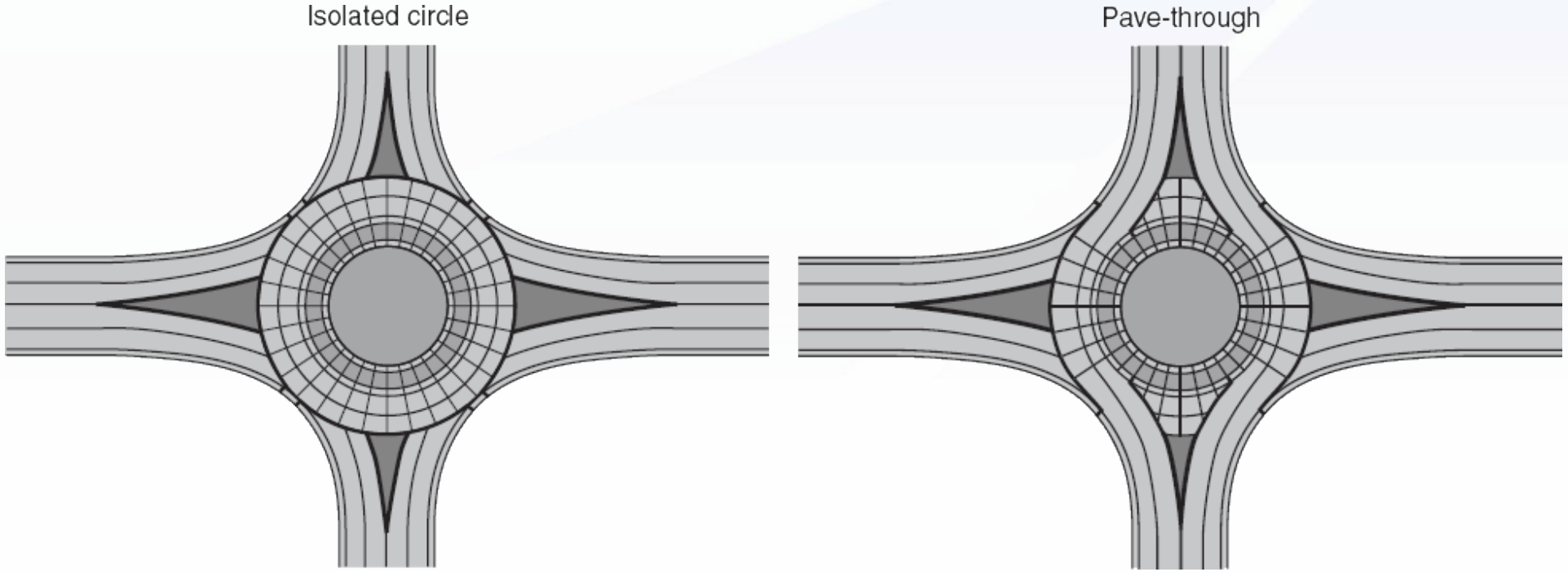
Jointing a Roundabout

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



Jointing a Roundabout

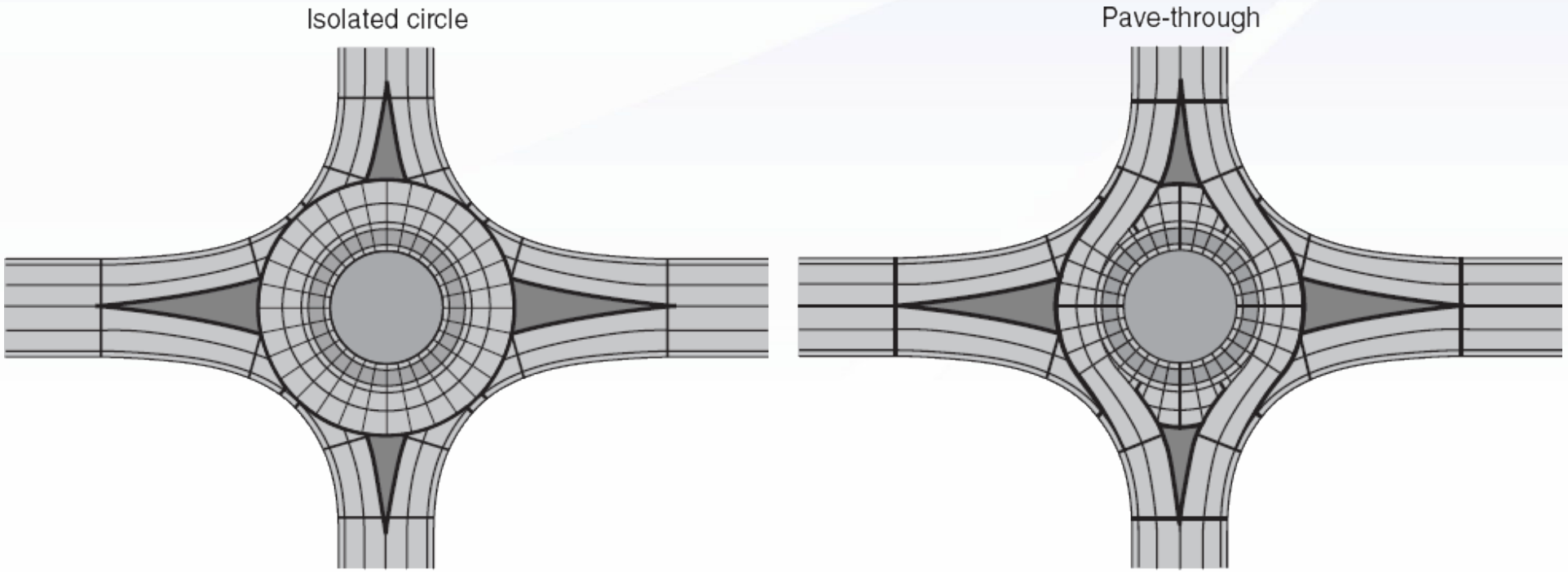
Step 3: Add “transverse” joints in the circle, being mindful of the maximum joint spacing.



Example – Isolated Truck Apron

Jointing a Roundabout

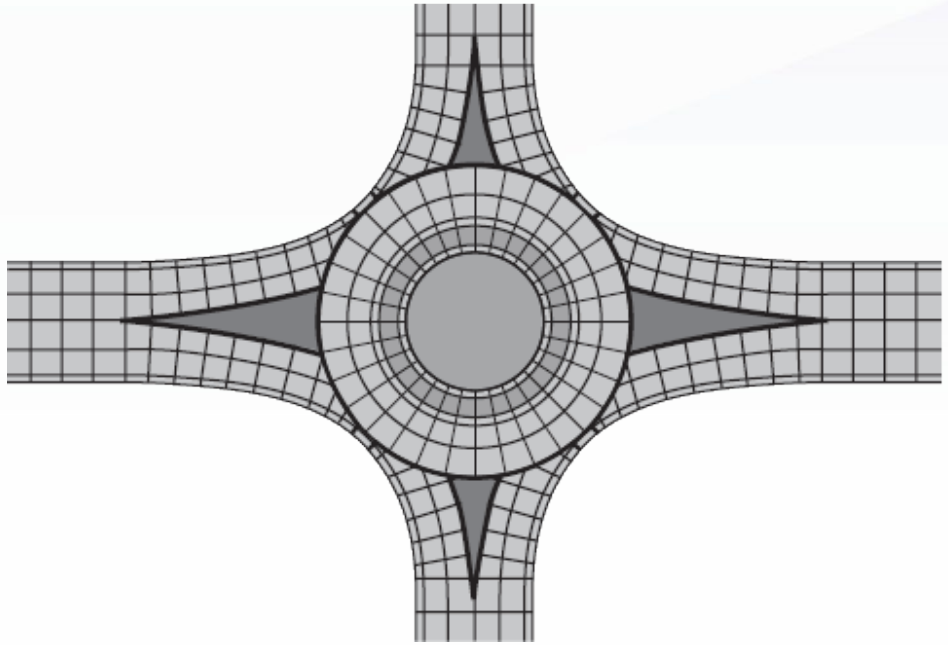
Step 4: On the legs, add transverse joints where width changes occur.



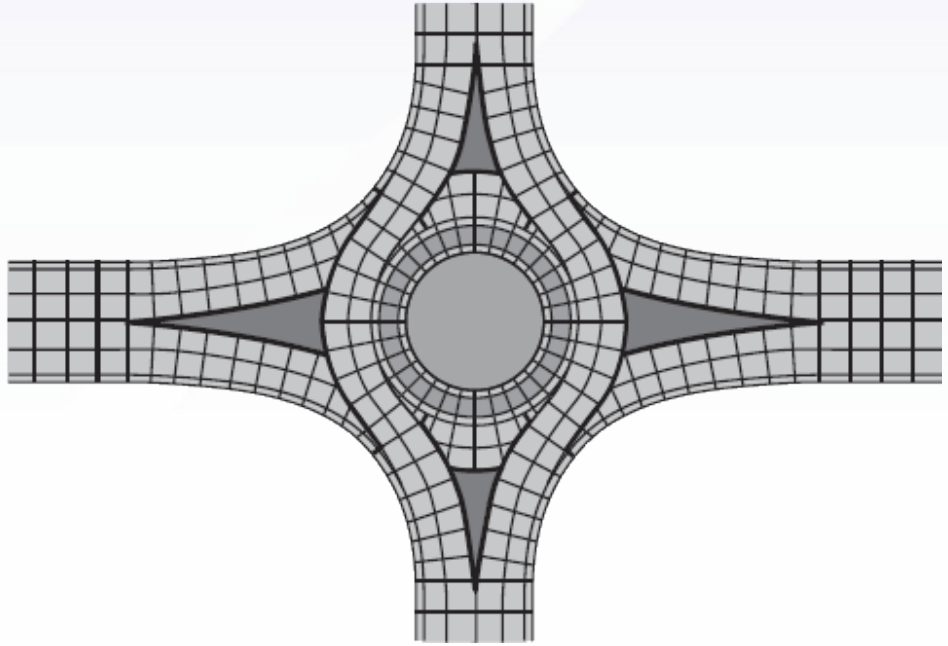
Jointing a Roundabout

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

Isolated circle



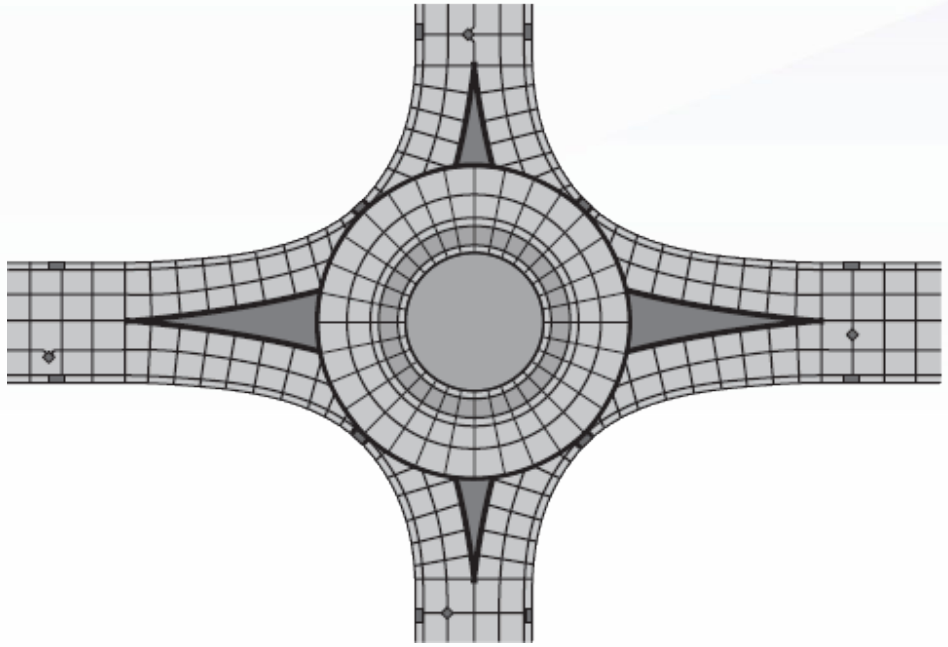
Pave-through



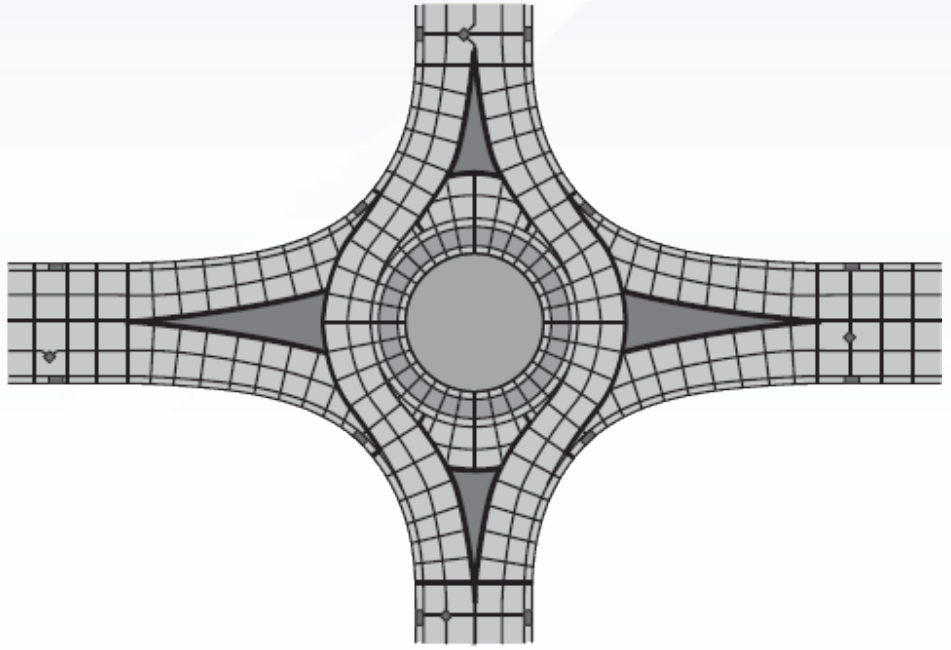
Jointing a Roundabout

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

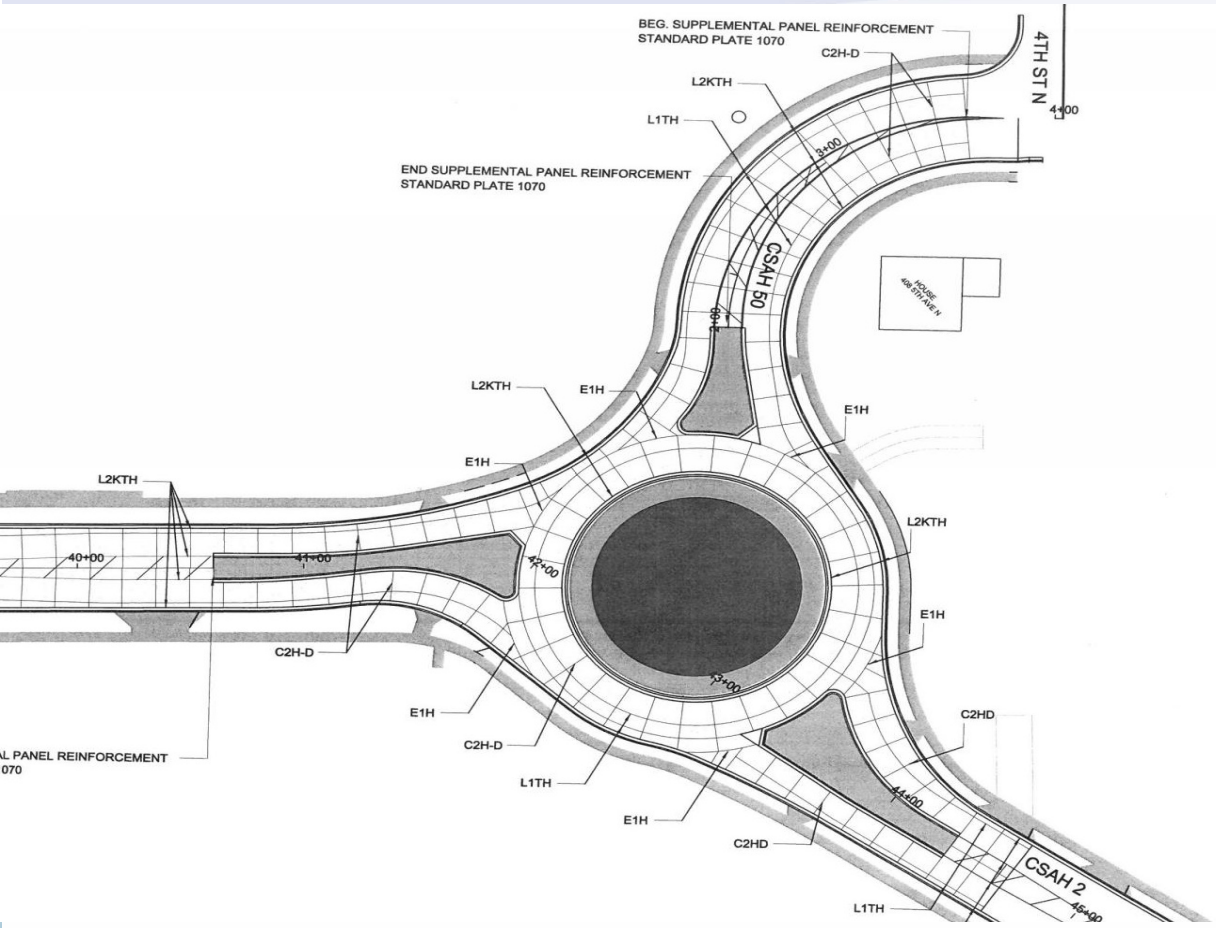
Isolated circle

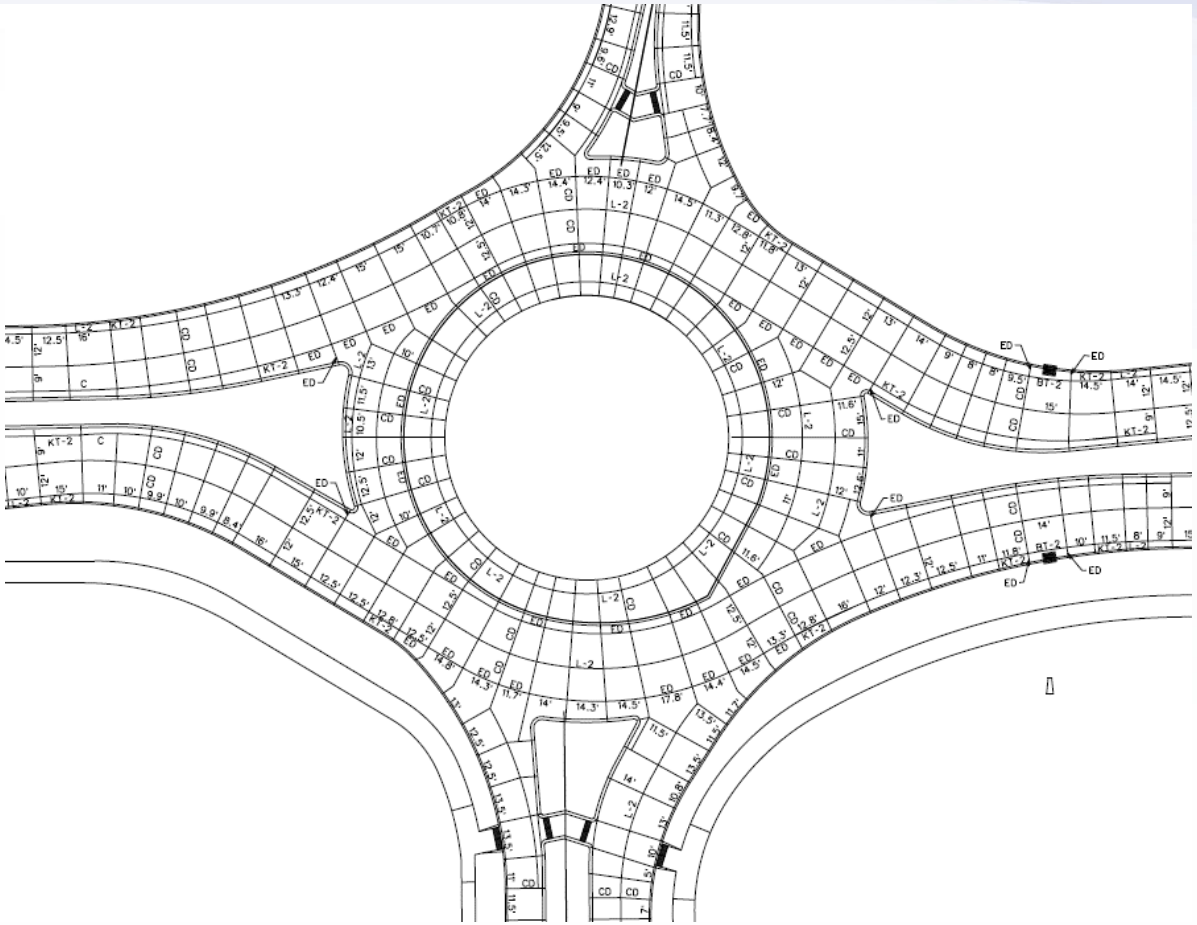


Pave-through



Both Methods Can Work



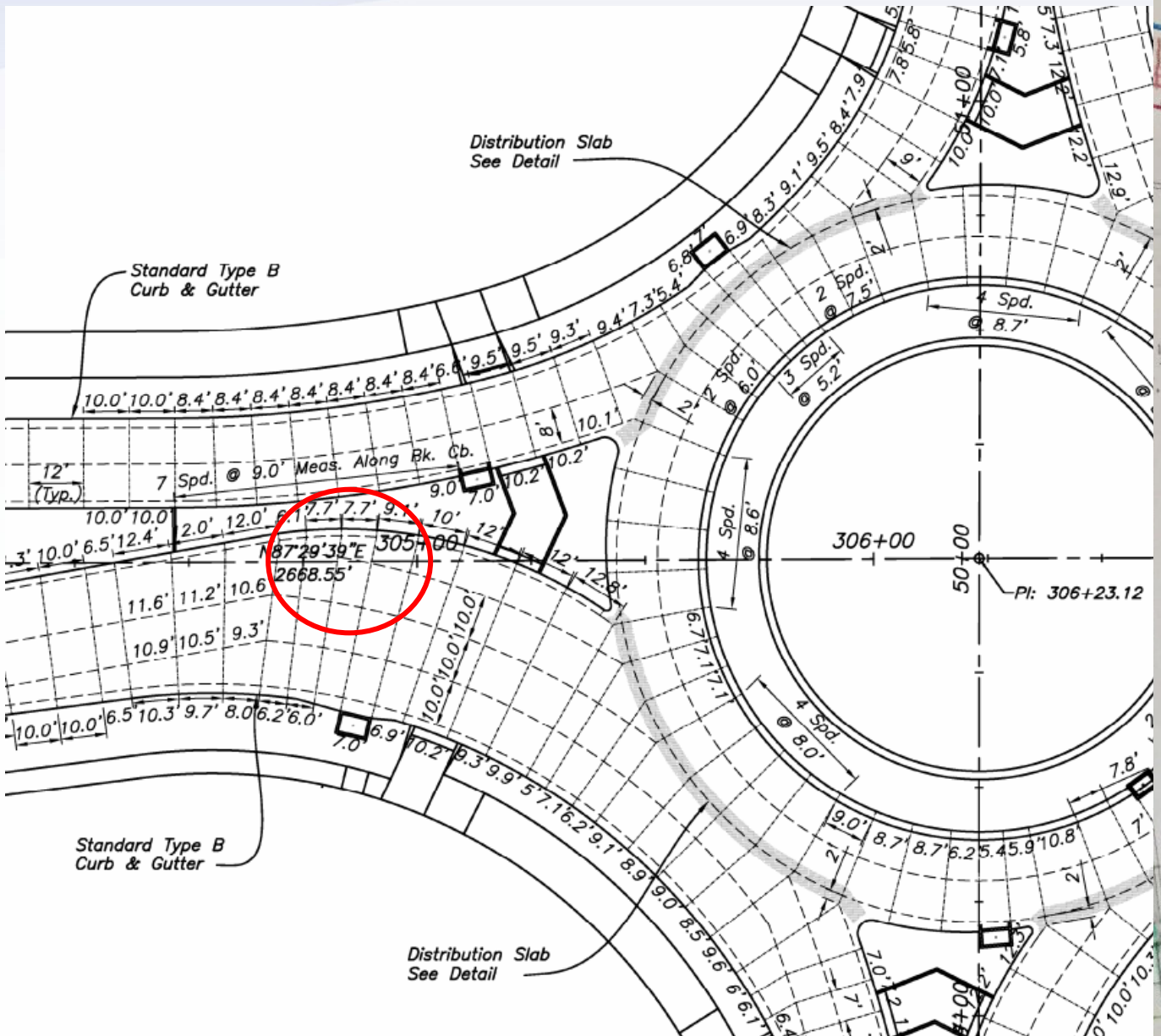


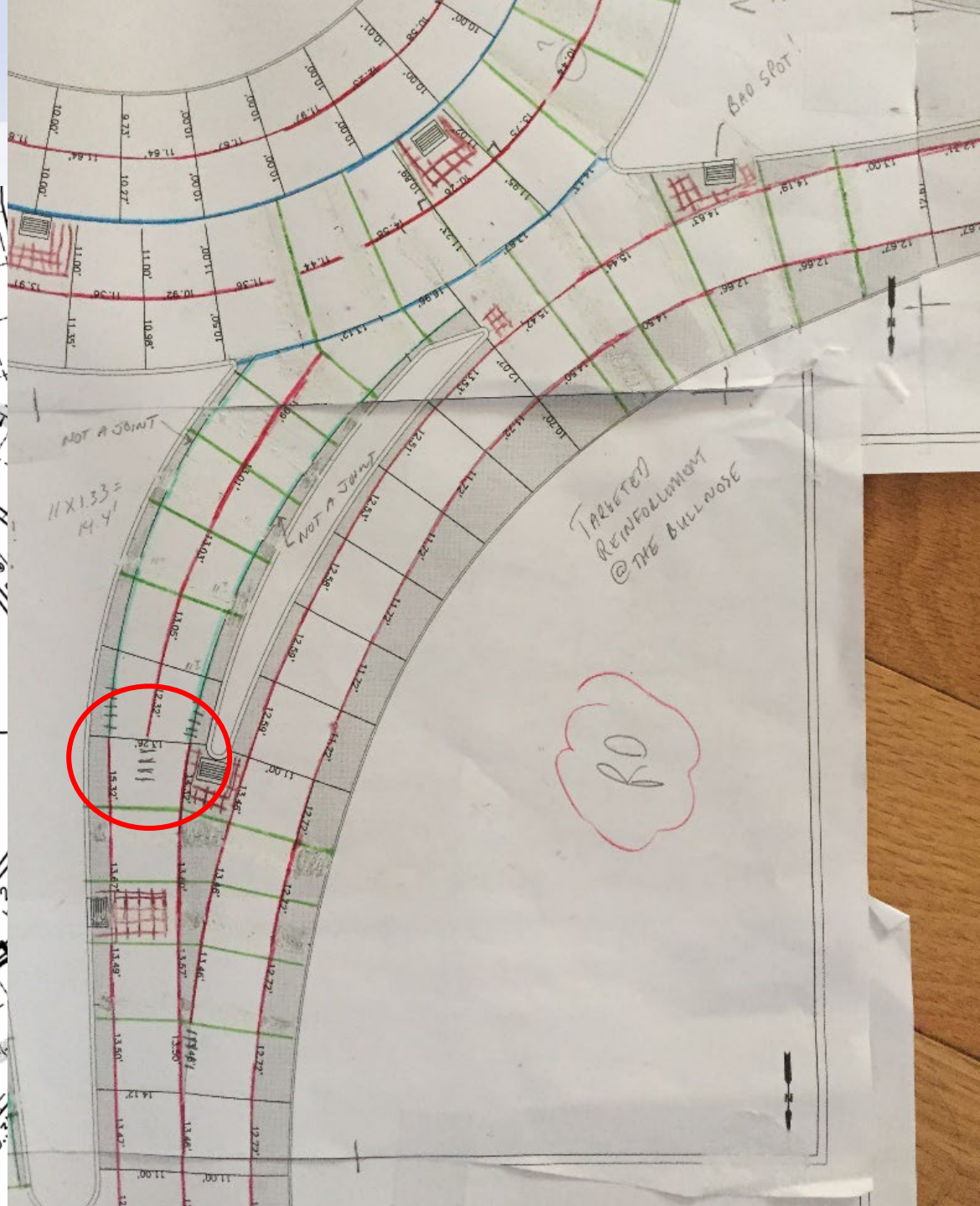
Images: CPAM (L), Snyder & Associates (R)

Properly Jointed Roundabout

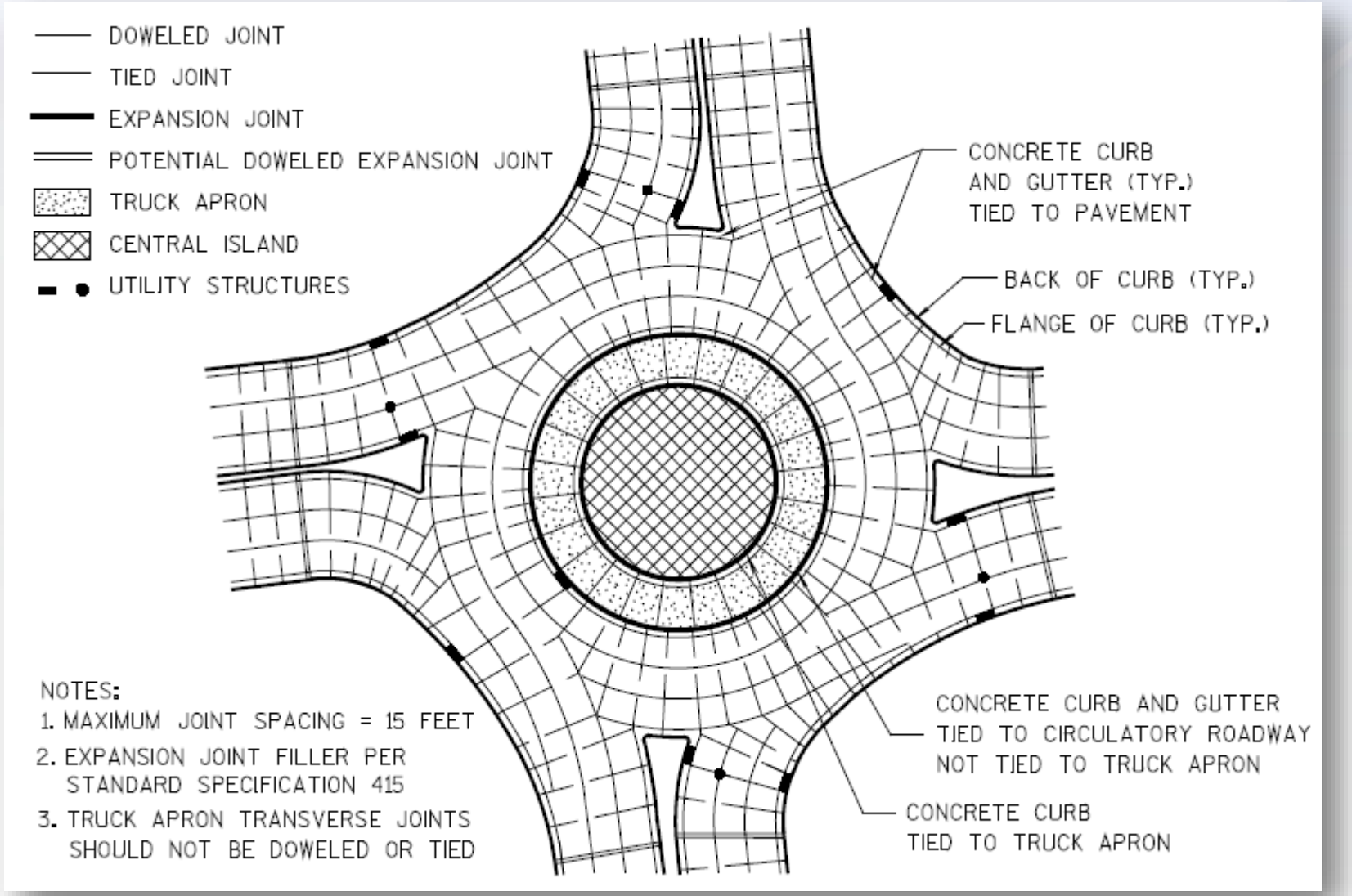
What If I Have an Odd Shaped Slab?

Dead-End Joint with Roundabouts





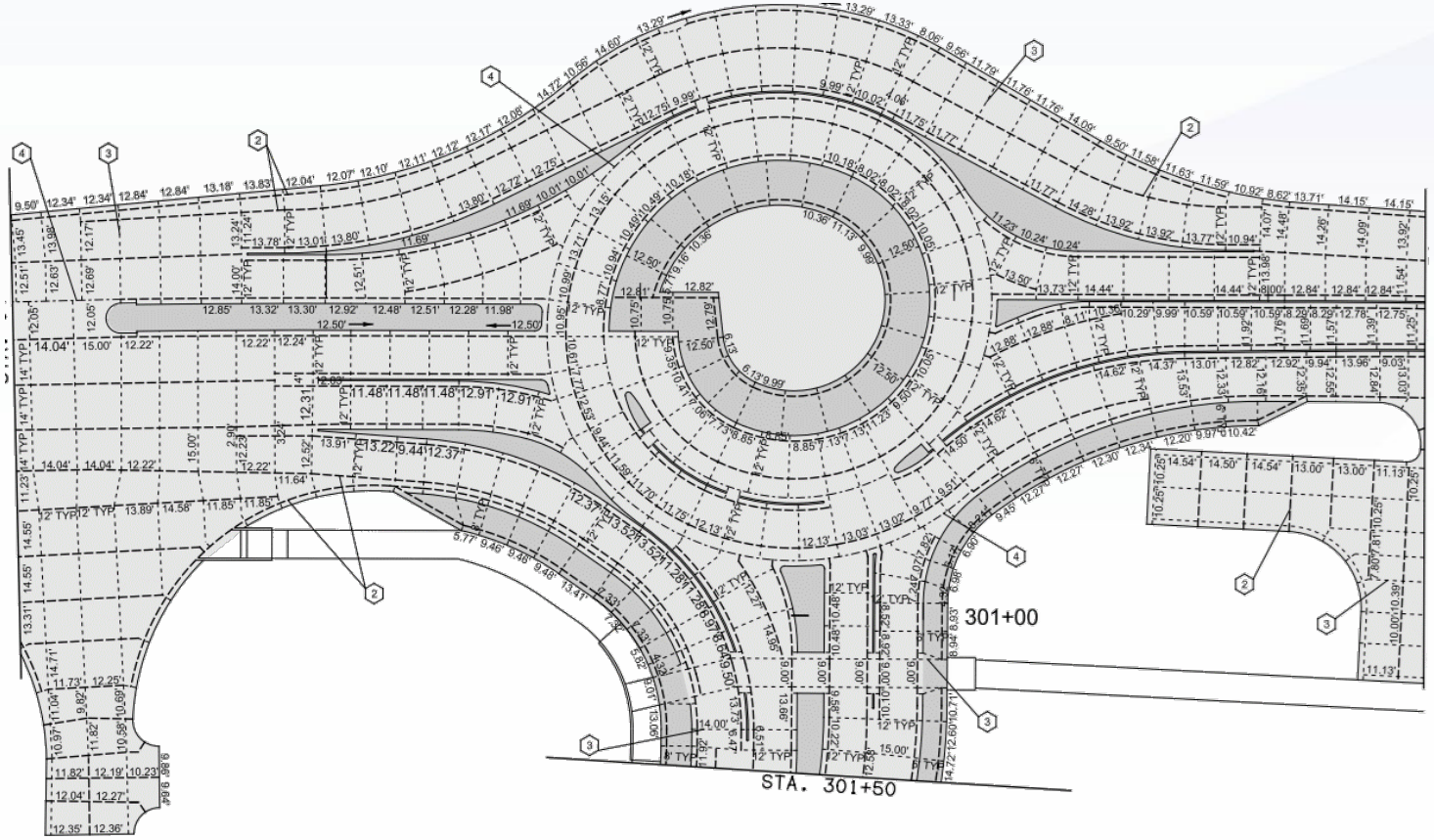
What If I Have to Dead-end a Joint?



Mixed Width (2 Lane & 1 Lane)

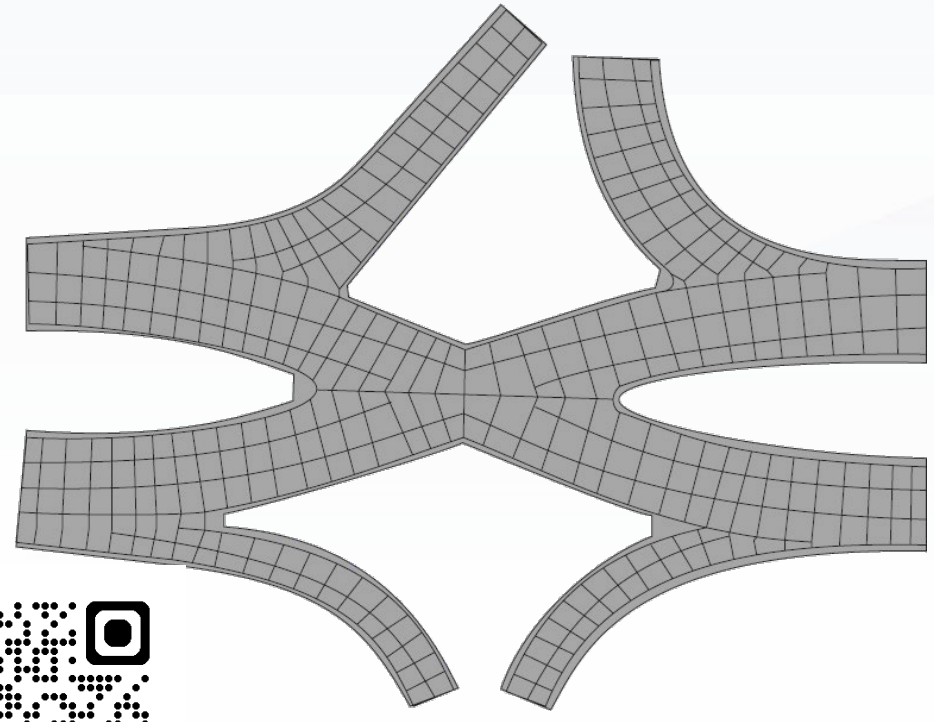
Turbo Roundabout

- Fort Riley, KS:

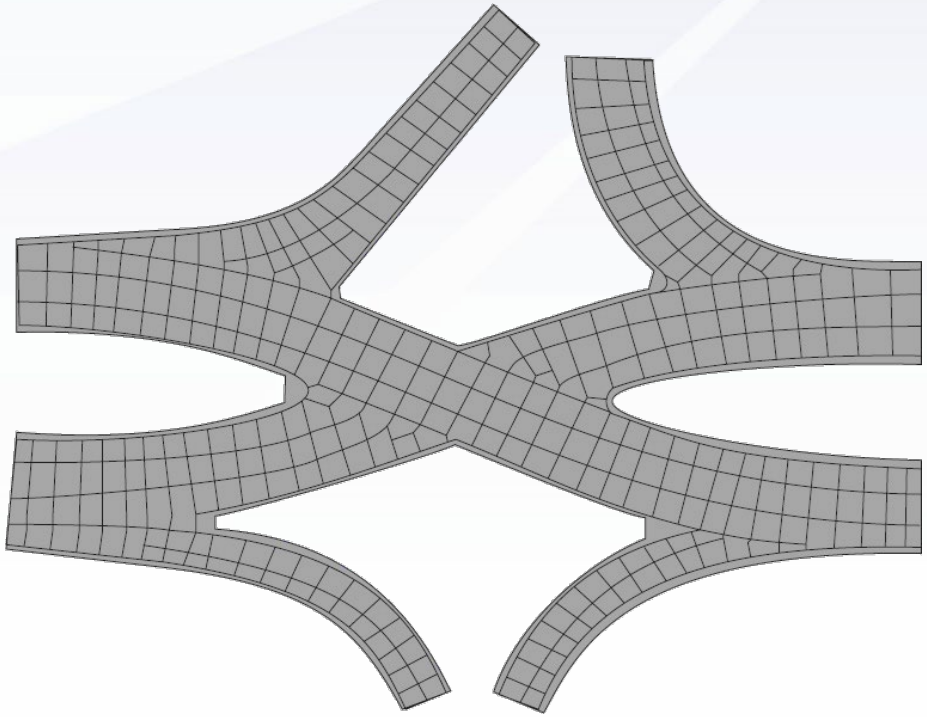


11 Step Method for Diverging Diamond Interchanges

Quadrant Method

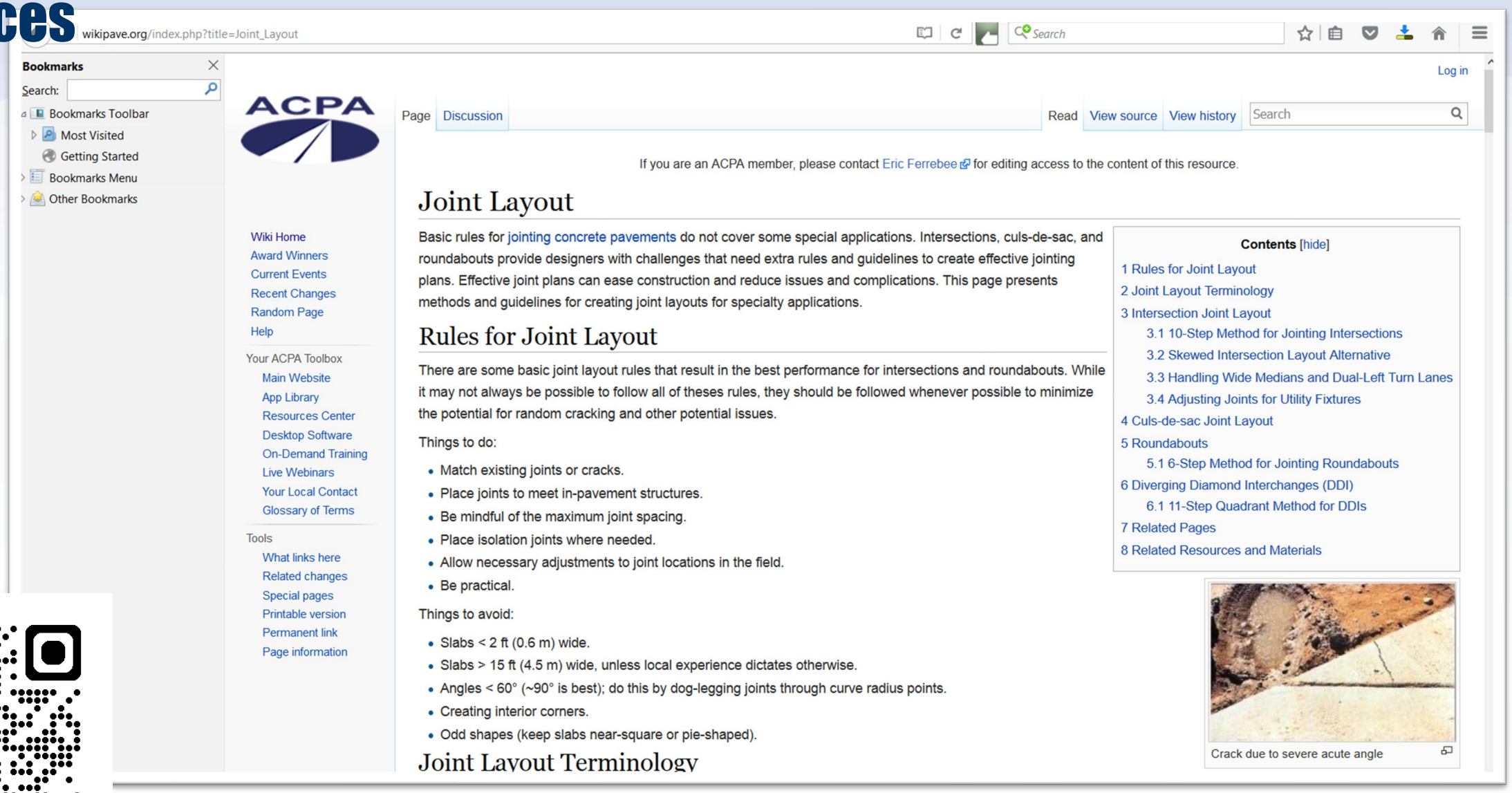


Pave-Through Method



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

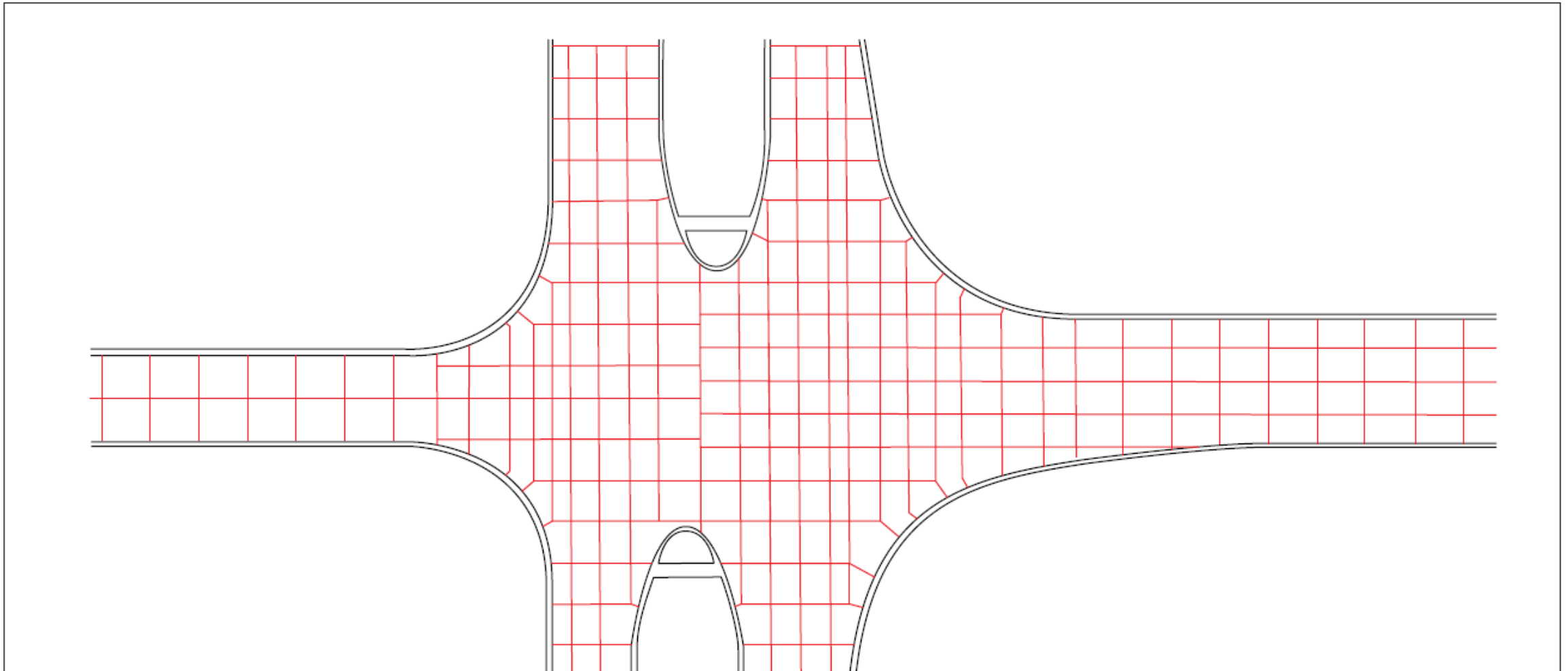
Resources



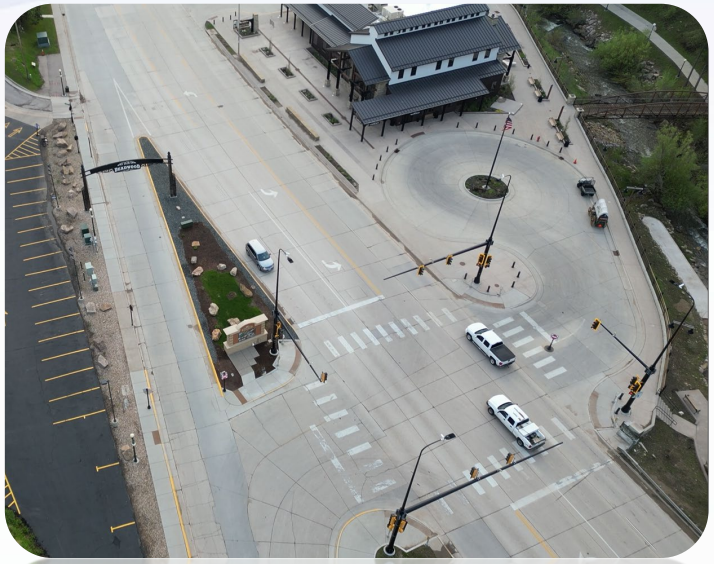
http://wikipave.org

Signs of a bad layout...

- Identify potential issues with the joint layout below.



Thank You! | Back to Dan!



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