JPCP Joint Layout – Best Practices

Presented by:

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Why Joint Concrete Pavements?

Concrete Shrinks!

Hydration Uses Water

Drying Shrinkage

Hot then Cold

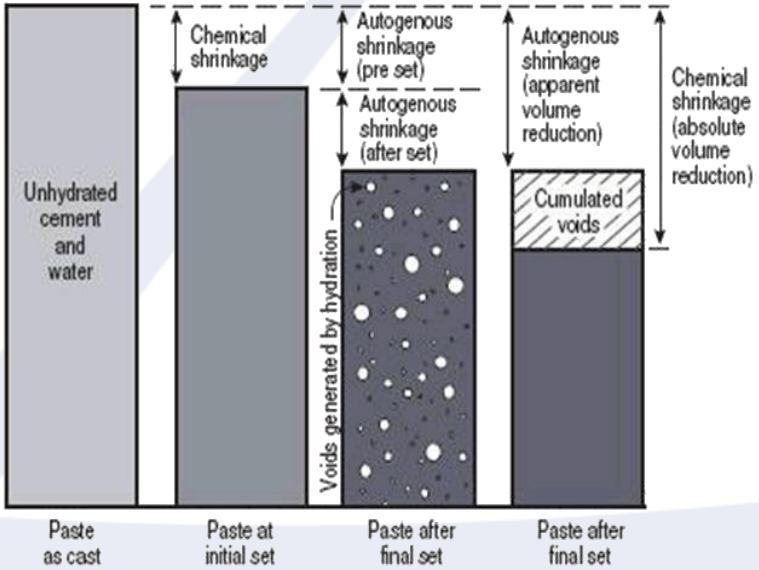
HOT AT SET

COOLED OFF

$$\Delta L = \alpha * \Delta T * L$$

Thermal Shrinkage

Chemical Shrinkage



Shrinkage + Restraint = CRACKS!?!

HOT AT SET, HIGH MOISTURE, UNHYDRATED CEMENT

If no restraint

COOL, DRY, HYDRATED CEMENT

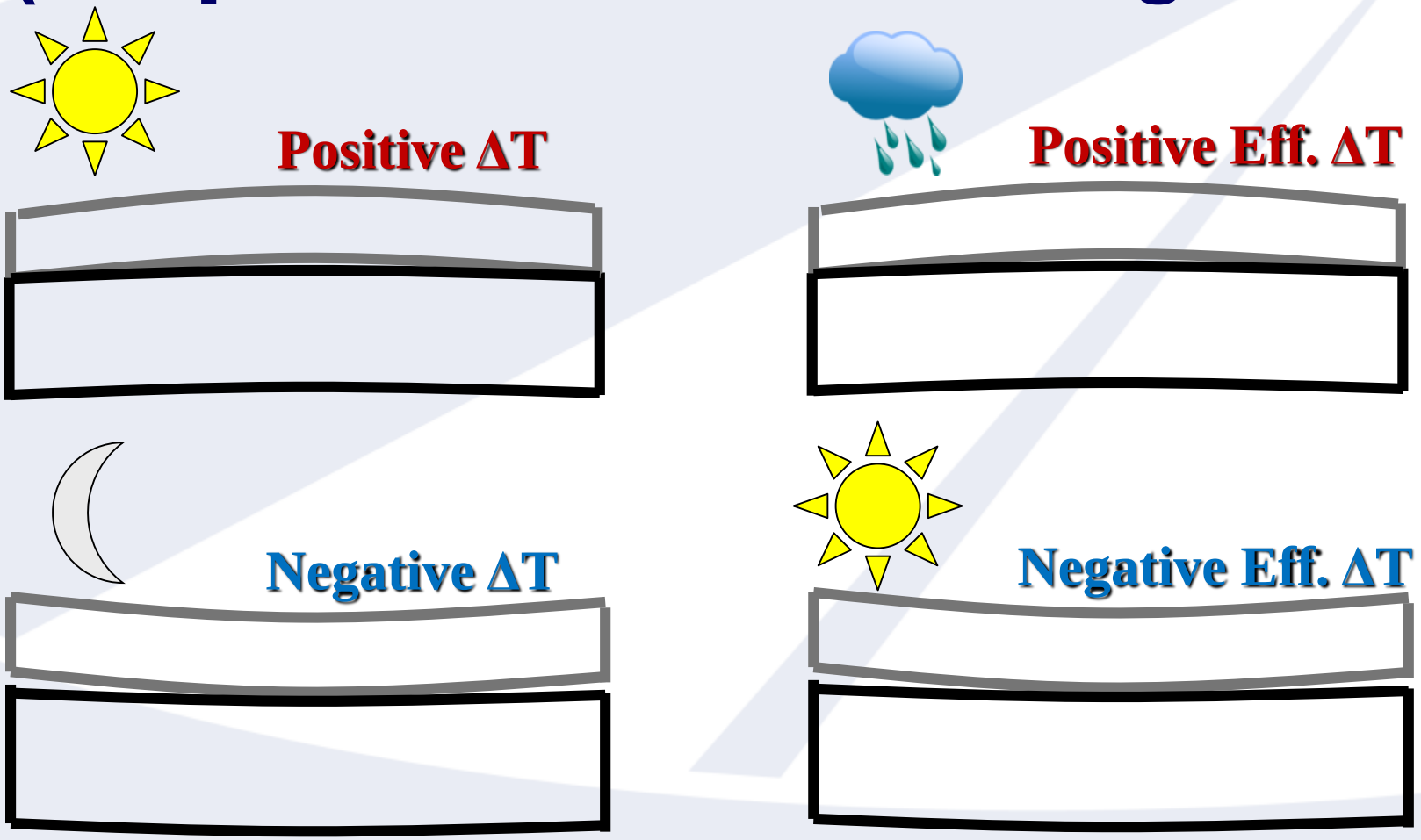
TEFLON | No Friction/Restraint

With restraint

Subgrade/Subbase | Restraint

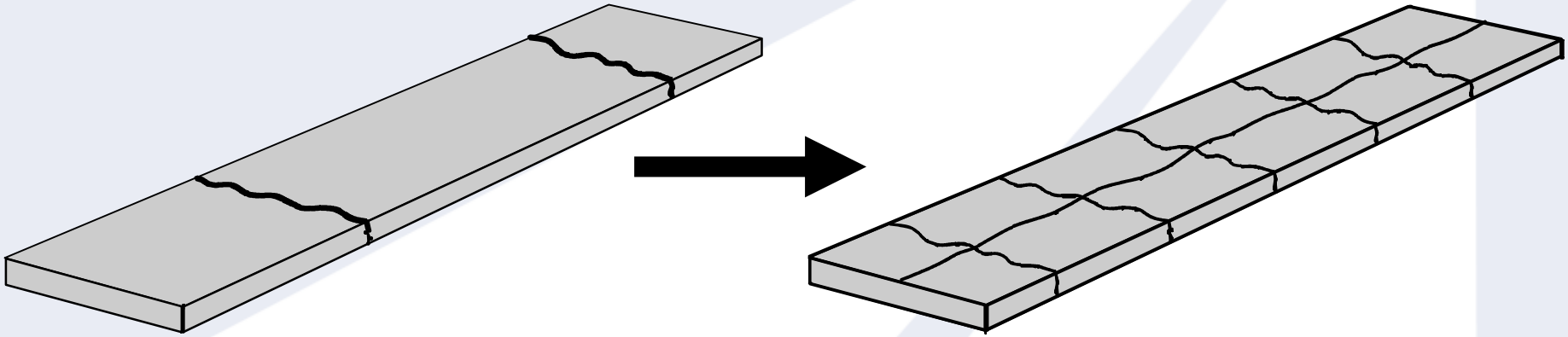
Curling and warping

(temperature and moisture gradients)



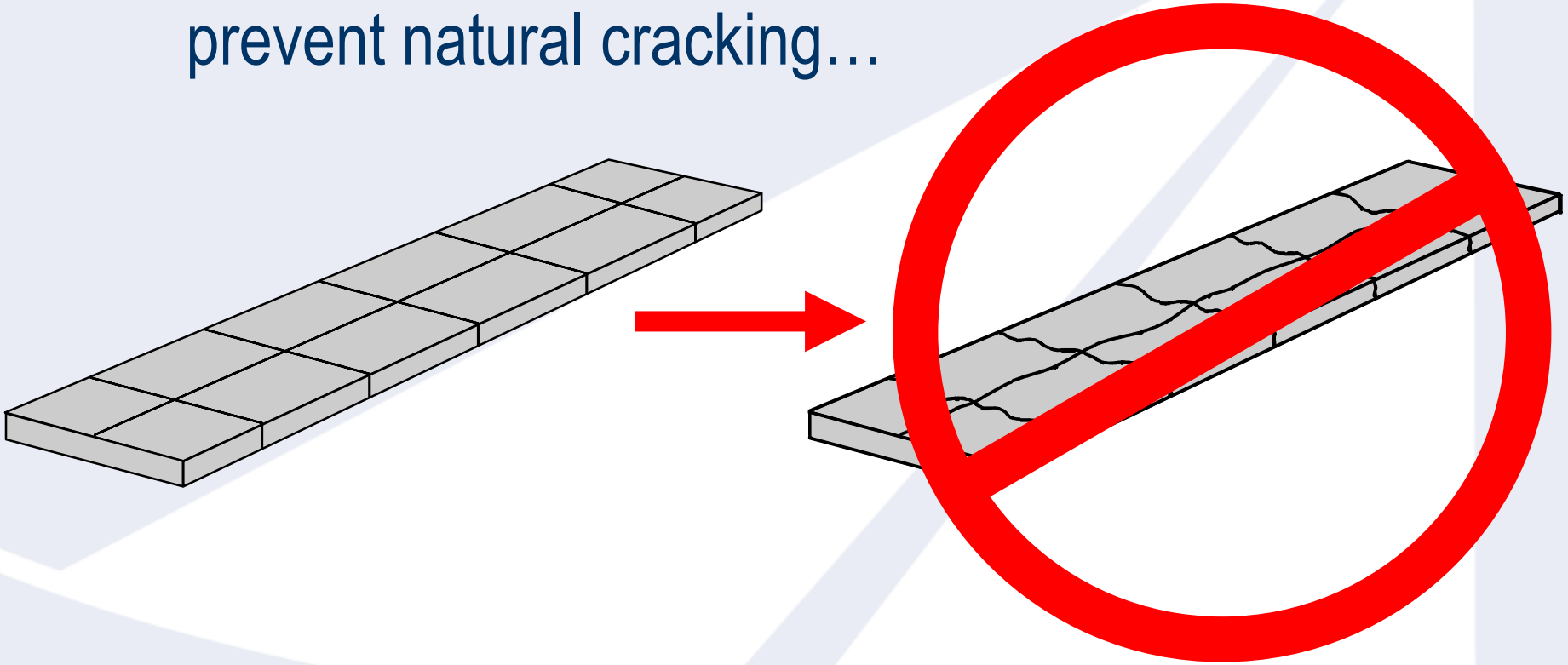
Why Joint Concrete Pavement?

- Without joints, natural transverse & longitudinal cracking would form about like this…



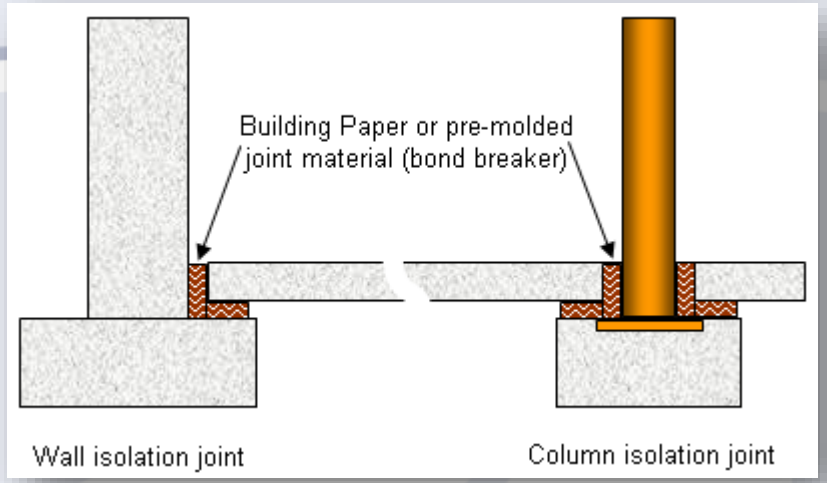
Why Joint Concrete Pavement?

- We place joints at a slightly shorter spacing to prevent natural cracking…



Conclusion:
Good Jointing is a Key to Good Performance

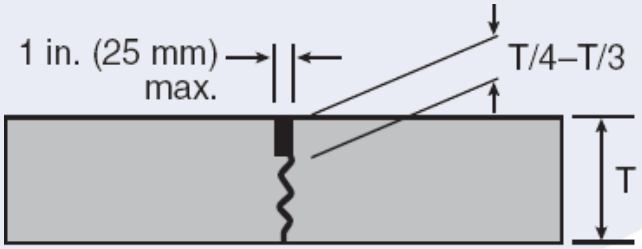
Types of Joints



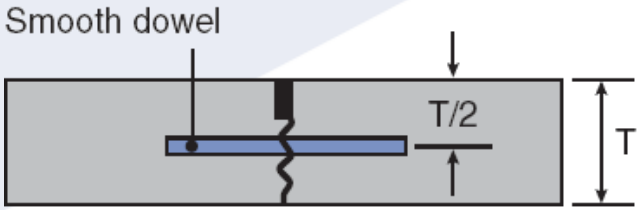
- Joint types:
  - Contraction
  - Construction
  - Isolation (and, if necessary, expansion)
- Each can occur in either the transverse or longitudinal directions.
- Also specialty joints (e.g., transitions, terminal joints in continuously reinforced, etc.).

Types of Joints

Transverse Contraction:



Undoweled – Transverse (Type A-1)

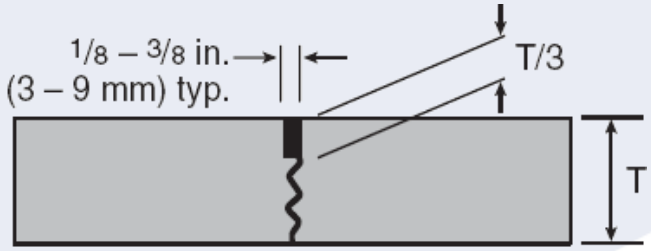


Doweled – Transverse (Type A-2)

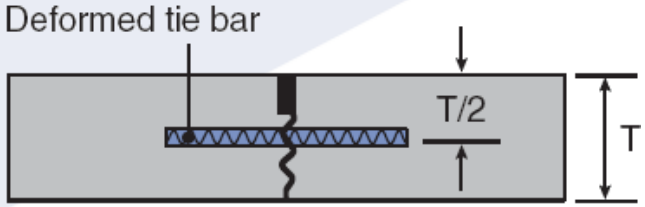
Skewed Joints

Types of Joints

Longitudinal Contraction:



Untied – Longitudinal (Type A-3)

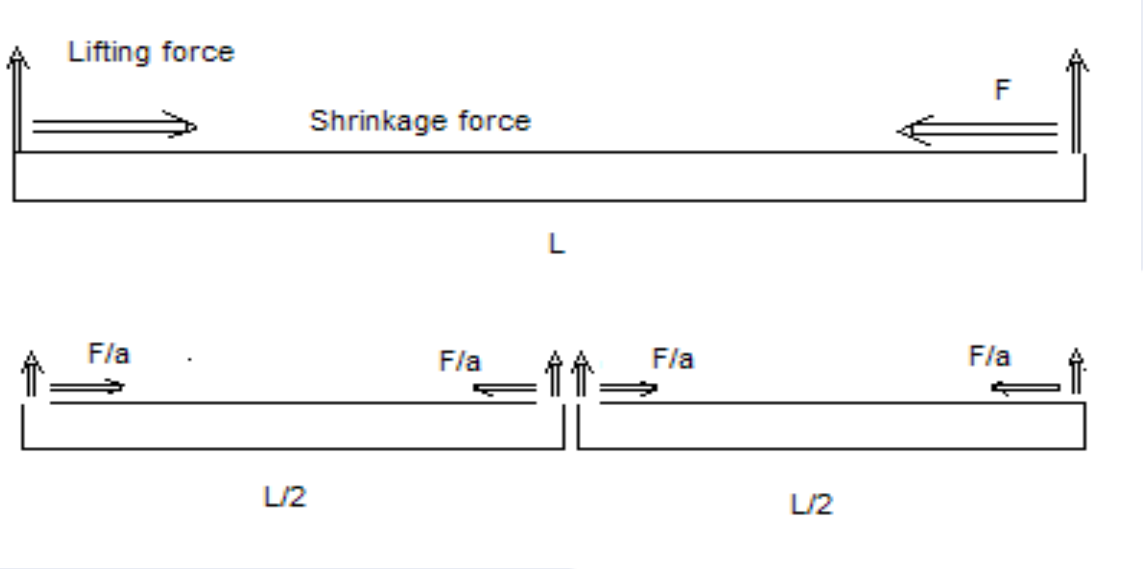


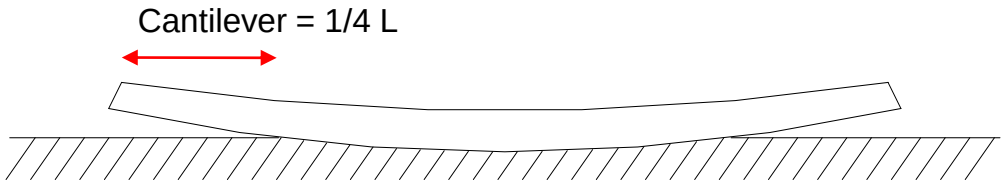
Tied – Longitudinal (Type A-4)

Joint Spacing and Placement Considerations

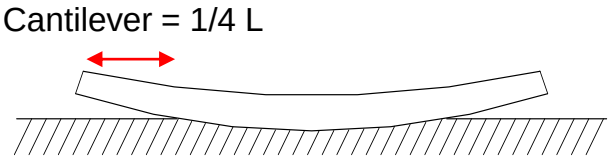
PANEL LENGTH AND ASPECT RATIO

Effects of Panel Length: Shrinkage and Curl/Warp Stresses



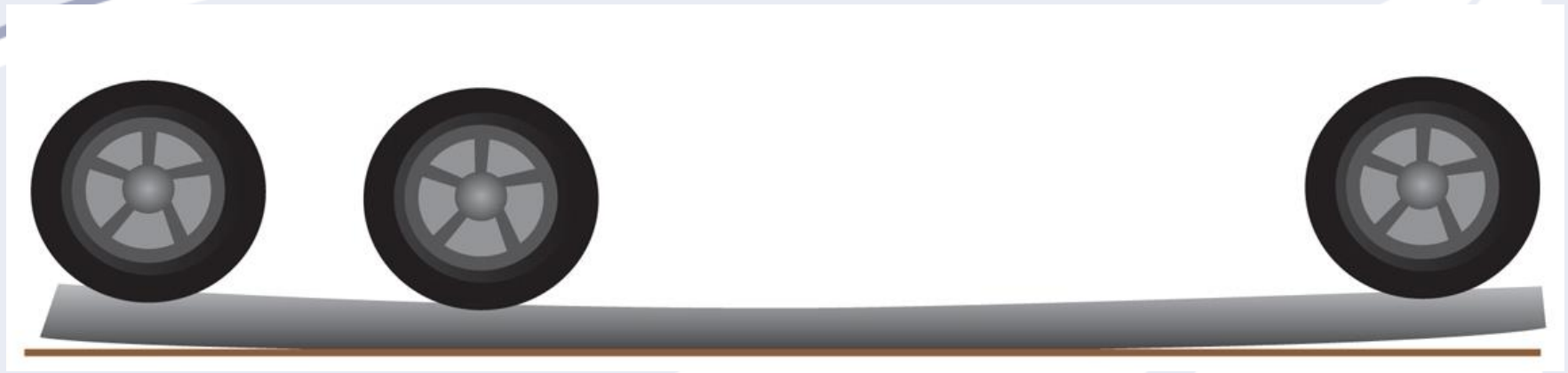


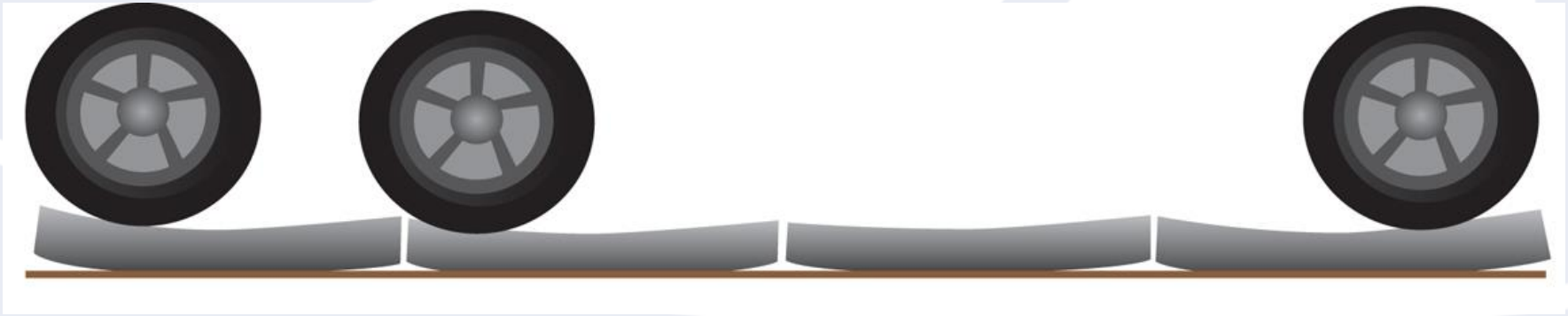
Length 12 to 15 ft., cantilever = 3 to 3.75 ft



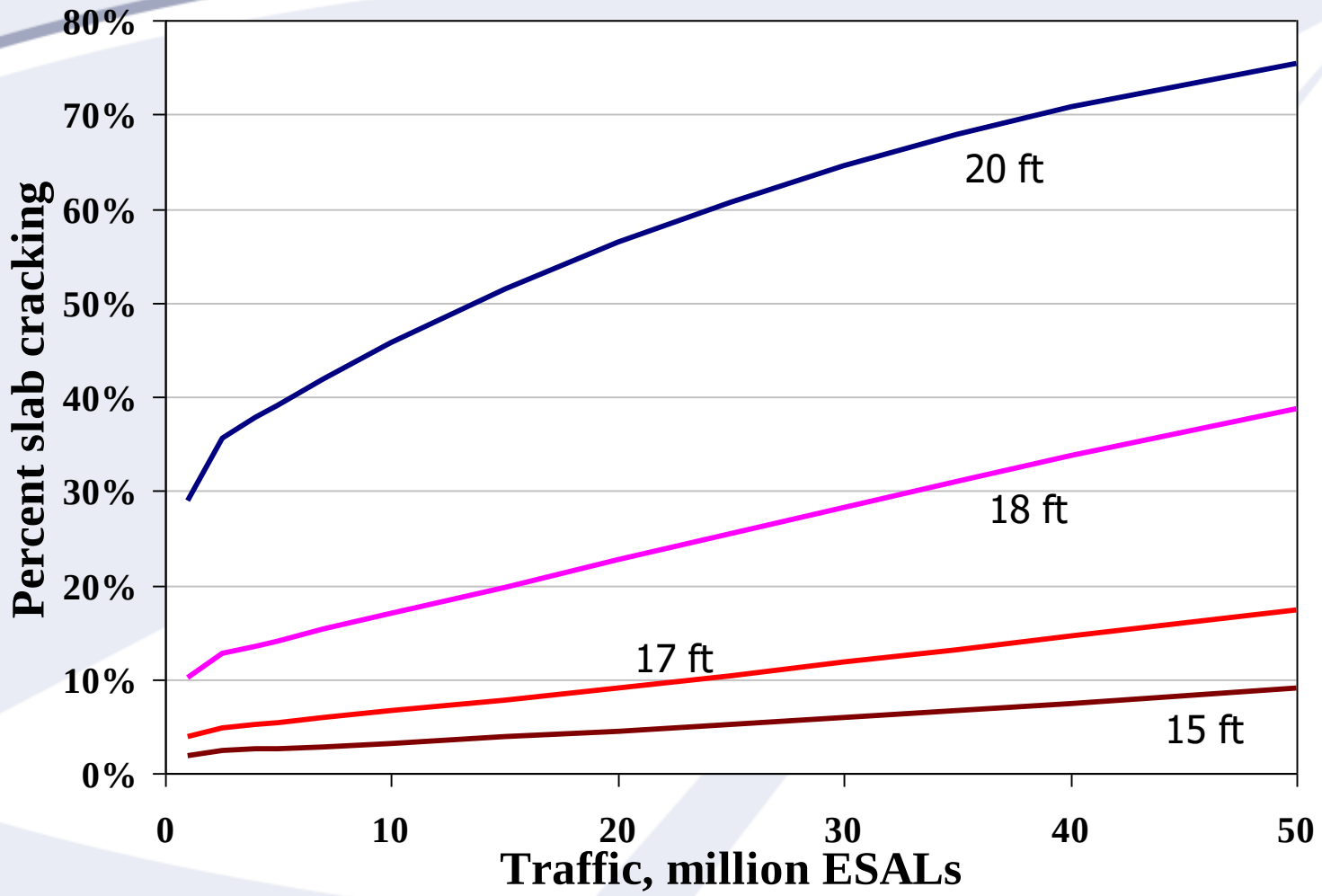
Length 6 ft., cantilever = 1.5 ft

Combined load and curl-warp stress





Effects of Joint Spacing on Slab Cracking



An MEPDG *example* for a specific pavement thickness and design conditions

Simple Formula for *JPCP* Maximum Panel Dimension (Joint Spacing)

$$L_{max} = T \times C_s$$

L_{max} = Maximum distance between joints (ft)

T = Slab thickness (in.)

C_s = Support constant

= 1.75 - 2 for subgrades or unstabilized [granular] subbases

= 1.5 - 1.75 for ATB, CTB, lean concrete [econocrete], or existing concrete or asphalt;

= 1 - 1.5 for bonded concrete overlays on asphalt (BCOA)

Rules of Thumb:

- Limit L_{max} to 15 ft for T < 10 inches unless local history shows longer panels work (e.g., low CTE of aggregate, granular base, light traffic, etc.)
- Keep aspect ratio (i.e., Length/Width) $\leq$ 1.5

There's an app for this …

Description

For jointed plain (unreinforced) concrete pavement (JPCP), the maximum allowable joint spacing or slab length depends on variables such the slab thickness, concrete aggregate used, cement content, subgrade/subbase used, and climate. In most areas, the typical maximum transverse joint spacing for JPCP used in applications such as streets, roads, and highways is about 15 ft (4.5 m); a longer maximum transverse joint spacing may be used, however, based on local experience. Longitudinal joint spacing on two-lane and multilane concrete pavements typically is about 10 to 13 ft (3.0 to 4.2 m). This tool provides an estimate of the maximum allowable joint spacing based on the slab thickness and the subgrade/subbase used, two of the variables with the most prominent effect on joint spacing requirements. Slabs kept to dimensions shorter than those calculated by this tool will have curling and warping stresses within safe limits to ensure minimal risk of random cracking.

Concrete Pavement Structure Details

Concrete Pavement Thickness (in.): 8 Metric

Layer Immediately Below Concrete Surface Course:

- ○ Subgrade
- ○ Unstabilized (Granular) Subbase
- ◉ Stabilized Subbase
- ○ Existing Asphalt Pavement
- ○ Existing Concrete Pavement

Calculate

Joint Spacing Recommendation

Maximum Joint Spacing: 14

Note: The ratio of transverse joint spacing to longitudinal joint spacing should not exceed 1.5.

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Alternate Criterion for *JPCP*
Maximum Panel Dimension (Joint Spacing)

$L/\ell < 4.5$ for stabilized base

$L/\ell < 5.0$ for unstabilized base

where: L = maximum panel dimension;

ℓ = radius of relative stiffness (slab-foundation)

$= (E_C h^3/12k(1 - \mu^2))^{0.25}$

There's an app for this, too!

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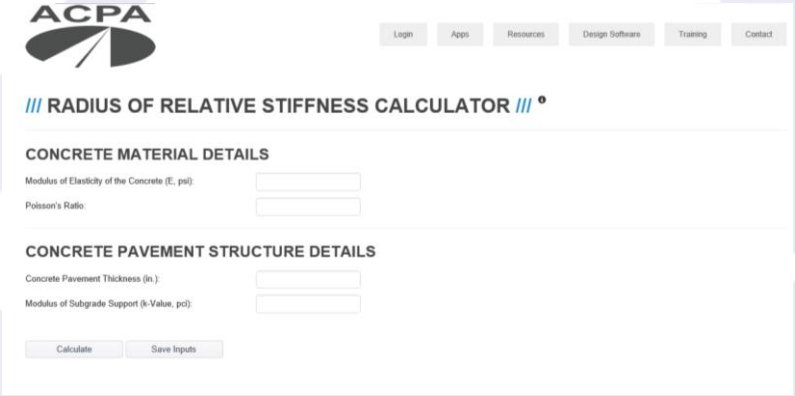


Other JPCP Joint Spacing Considerations

Use of "Randomized" Spacing (12'-13'-18'-19' or similar)

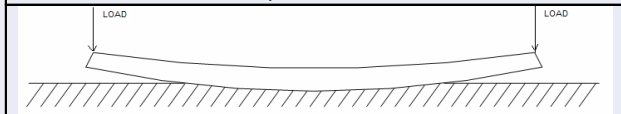
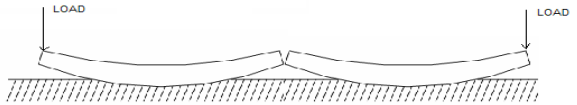
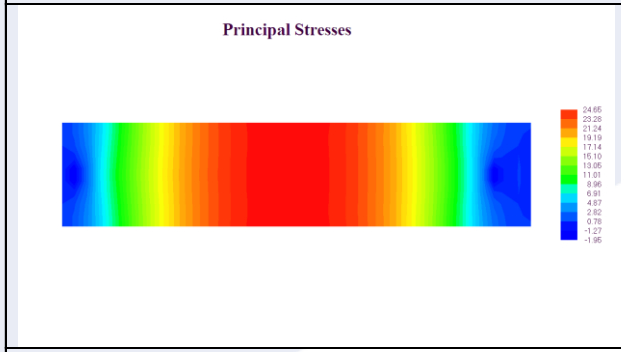
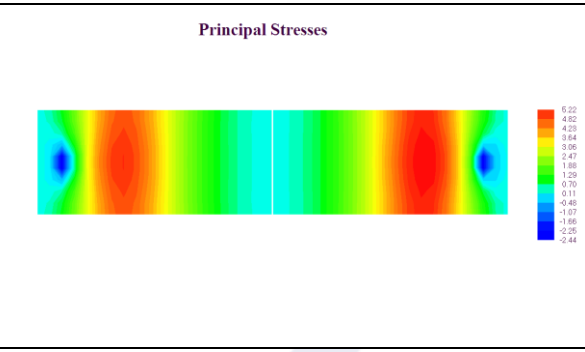
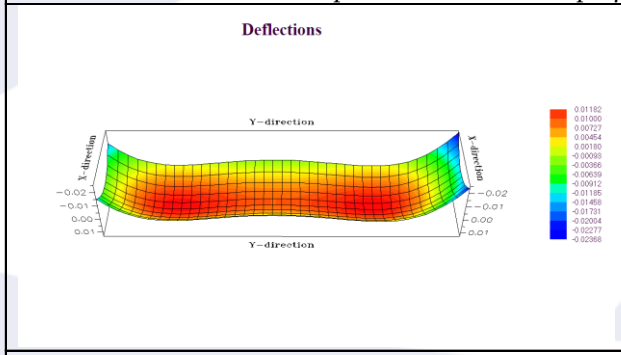
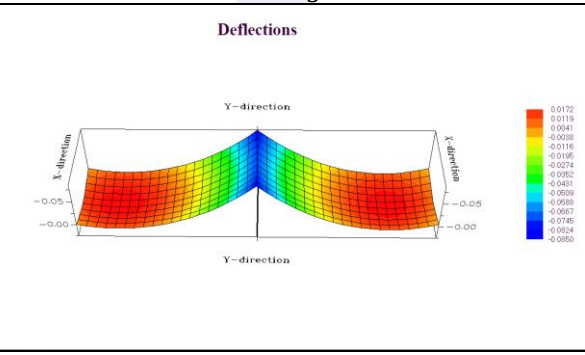
- Reduce potential for resonant vehicle responses
- Max. jt spacing in "random" sequence should still be selected to avoid cracking (18-19 ft almost always exhibit cracking)
- Typically used with skewed joints (1:6, right ahead)
- Popular in late '70s and '80s, not common now (corner cracking problems, more complex joint repairs)

"Optimize" Joint Spacing

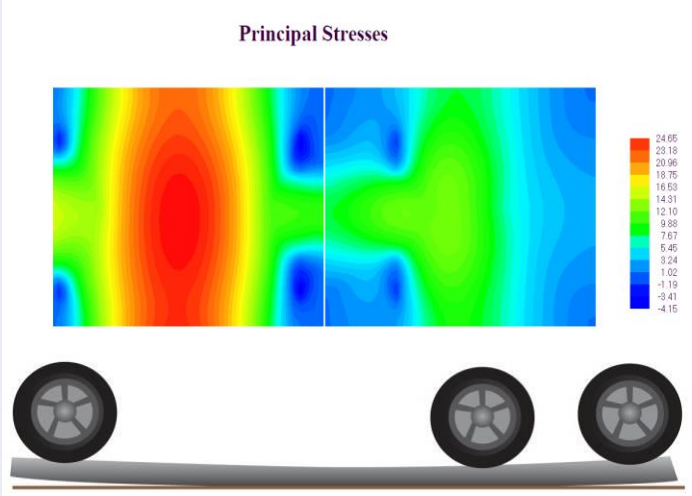
- Avoid midpanel cracking
- Limit number of joints (more cost effective)
- Limit opening of undoweled joints to 0.03 in

TCPavements®

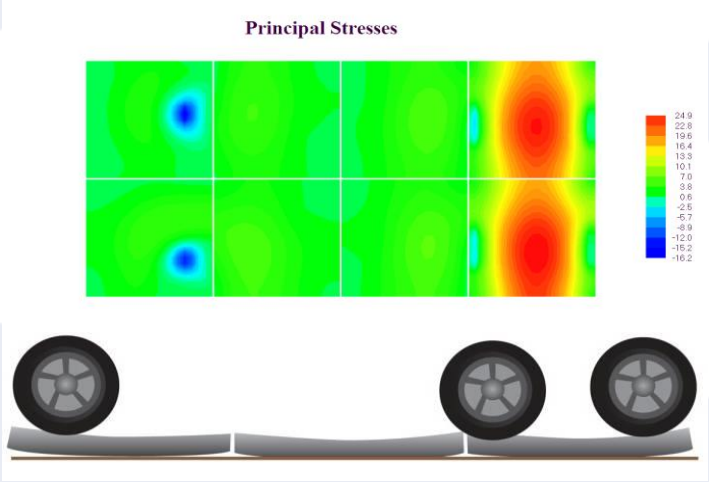
Influence of slab geometry on stresses

4,5m x 1m	2.25 m x 1 m
	
	
Maximun tensile stress = 24.65 Kg/cm2	Maximun tensile stress = 5.22 Kg/cm2
Principal stresses on the top of the slab, Red is tensile strength	
	
Deformation of the slab	

Slab sizes and thicknesses for same top stress (2.5MPa)



Thickness: 10 inches
Concrete
Slabs 14.8 ft x 11.8



Thickness: 6.3 inches
Concrete
Slabs 5.9 ft x 5.9 ft

Guatamala – 2007 Construction

Hundreds of lane-miles have been constructed in South and Central America over the last 10 years

Joint Spacing “Best Practices” Summary

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

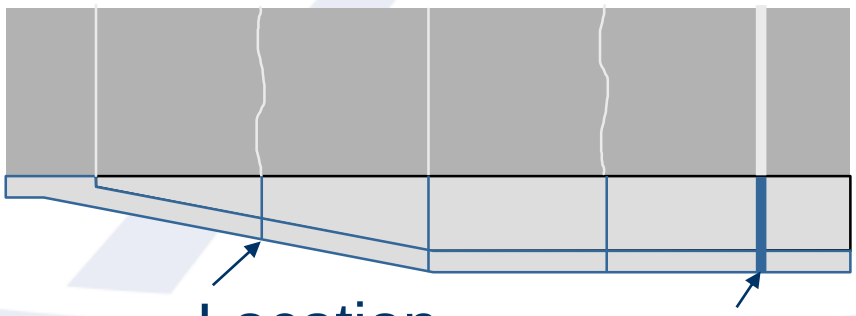
Joint Spacing and Placement Considerations

JOINT LAYOUT

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

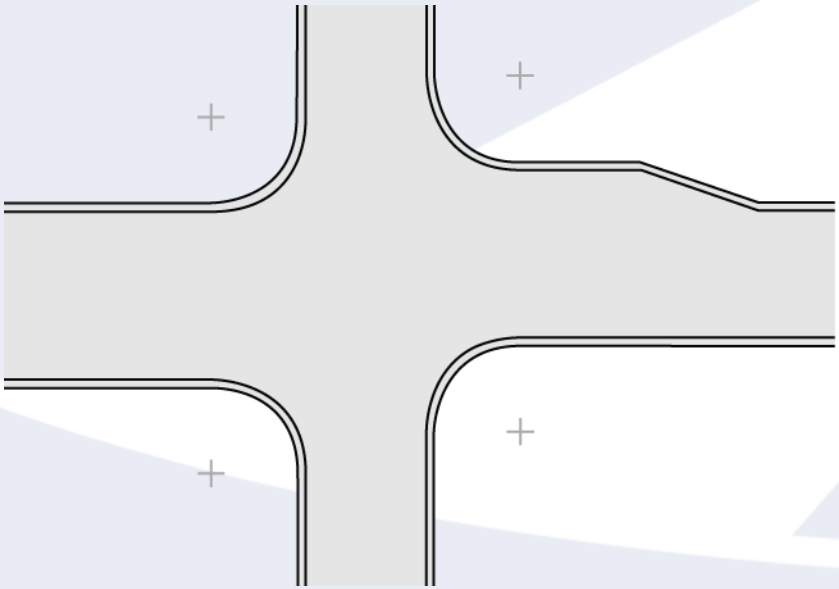
Things to Avoid:

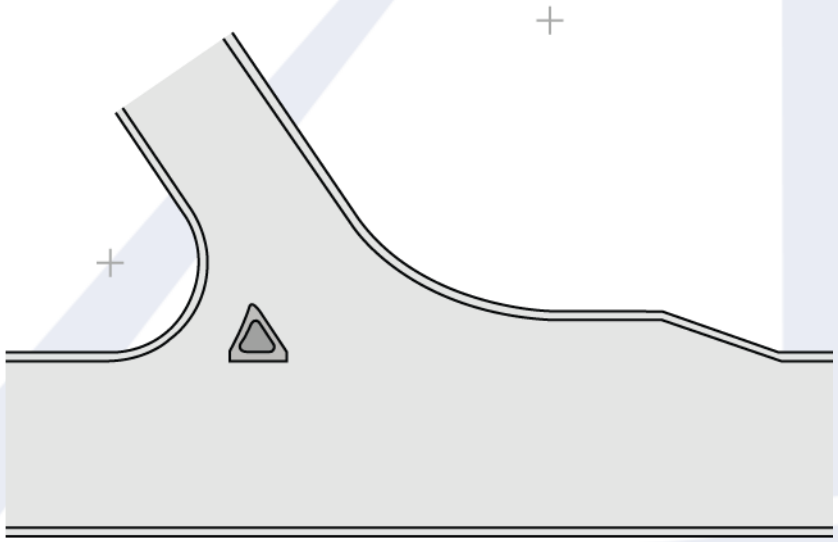
- Slabs < 2 ft wide
- Slabs > 15 ft wide
- Angles < 60º (90º is best)
  - Use “dog-leg” joints through curve radius points
- Creating interior corners
- “Odd” shapes
  - Keep slabs nearly square or rectangular, when possible

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.

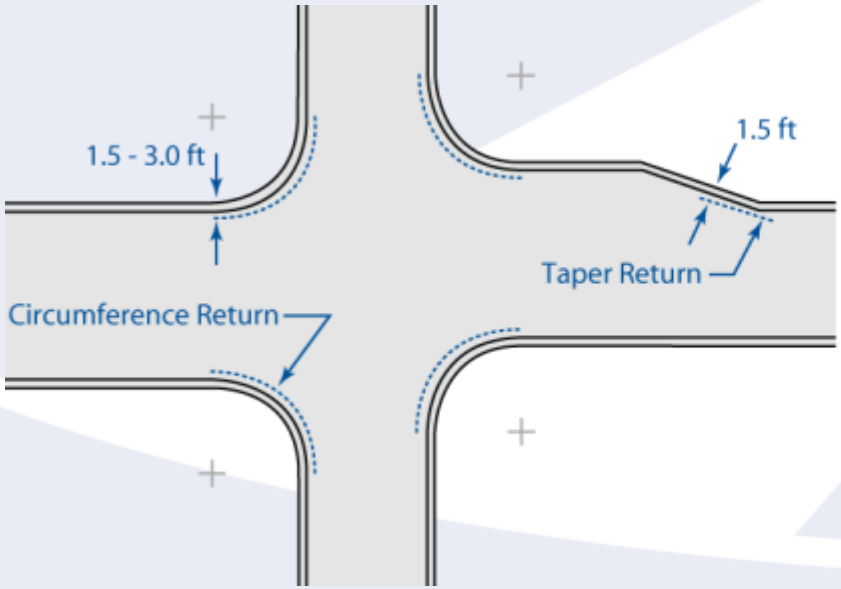


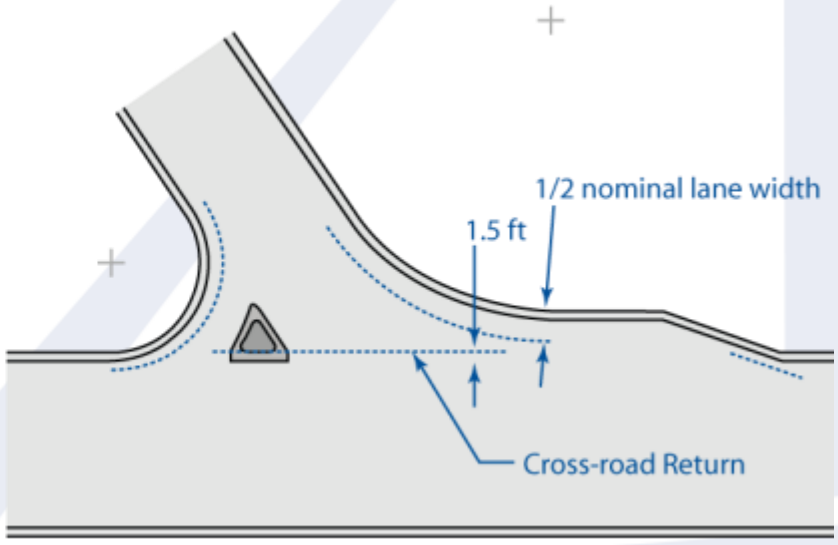


Concrete Intersections: Jointing

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

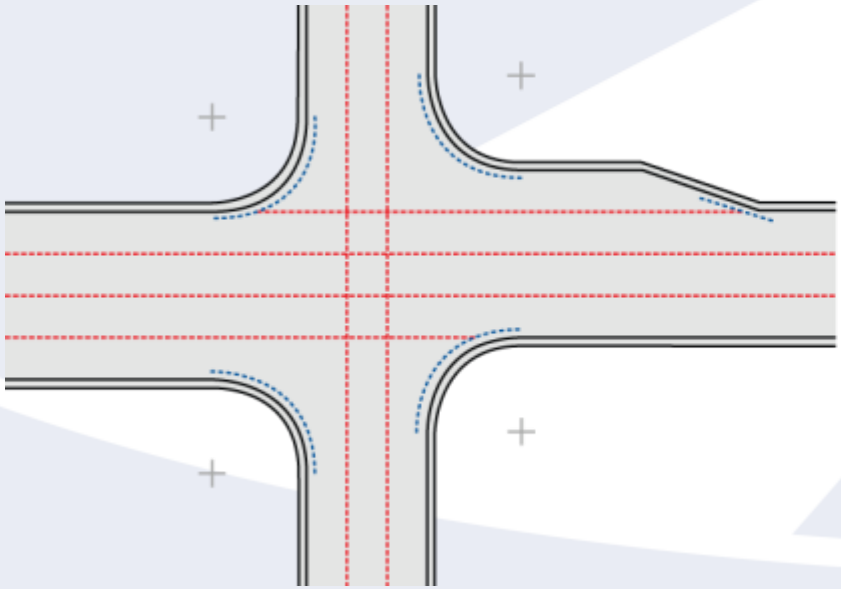


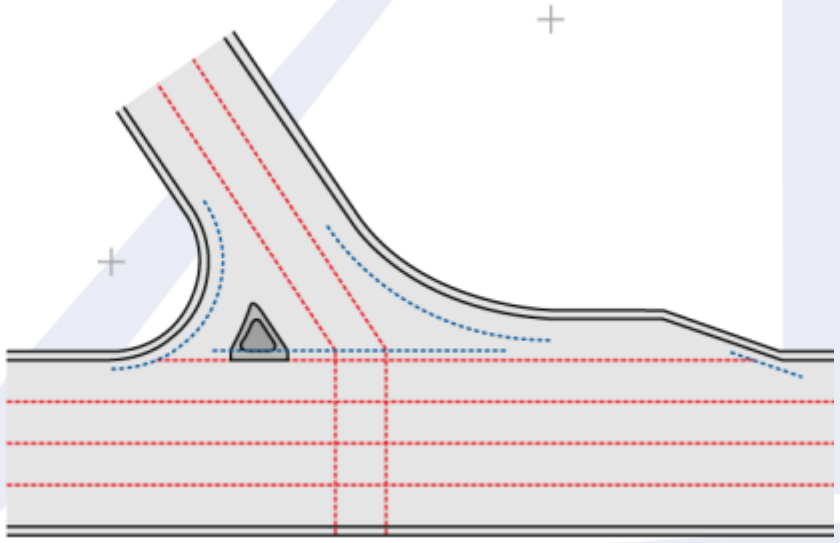


Concrete Intersections: Jointing

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).

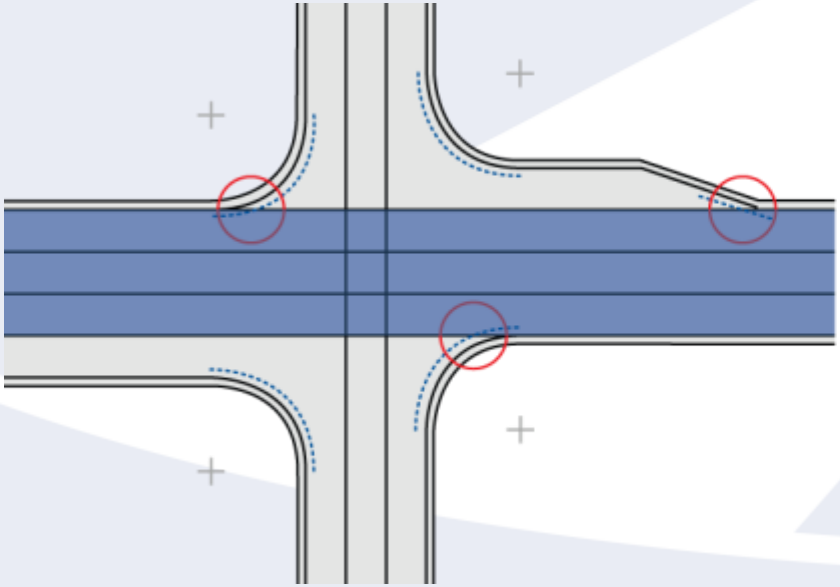


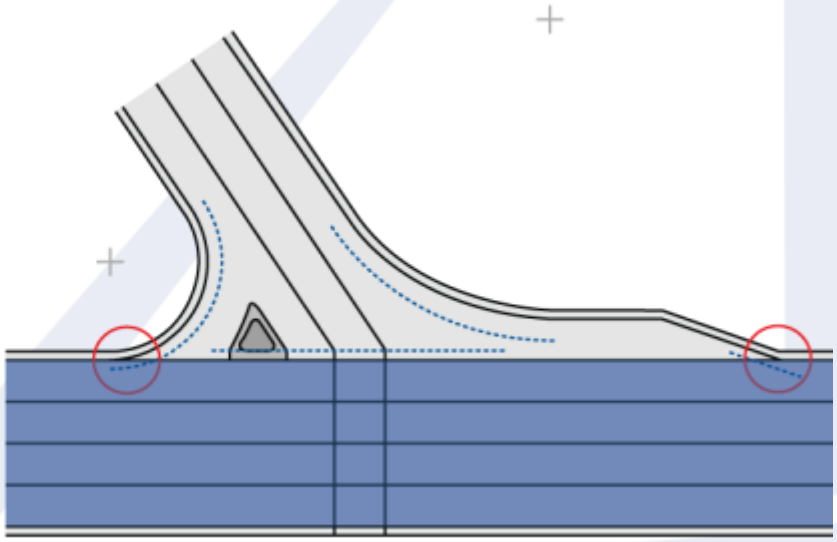


Concrete Intersections: Jointing

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.

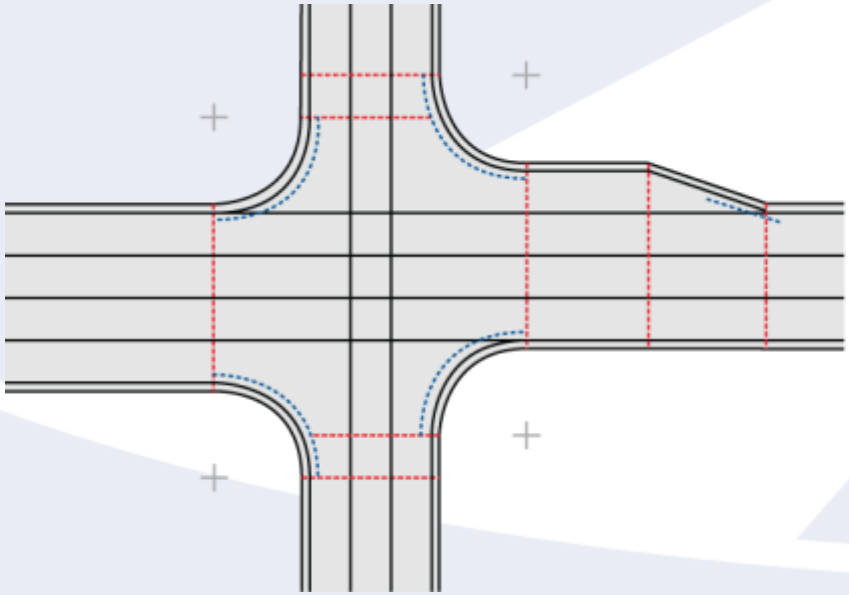


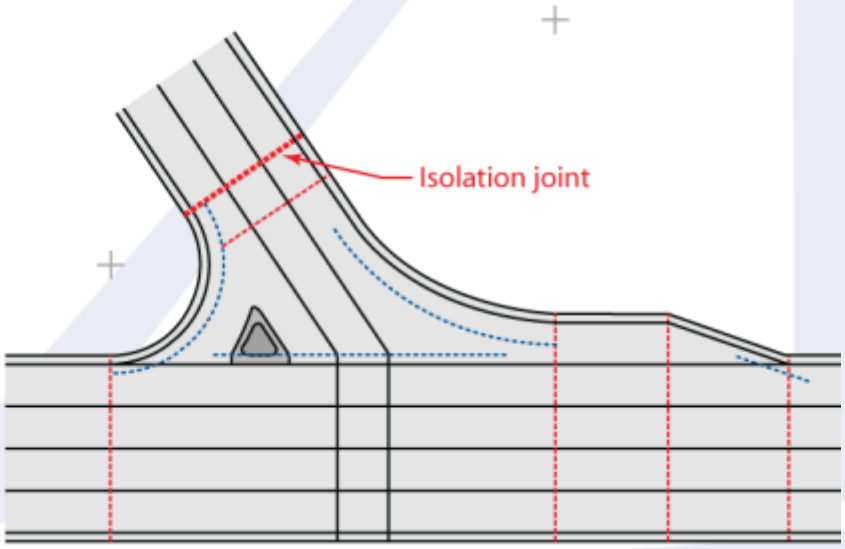


Concrete Intersections: Jointing

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.

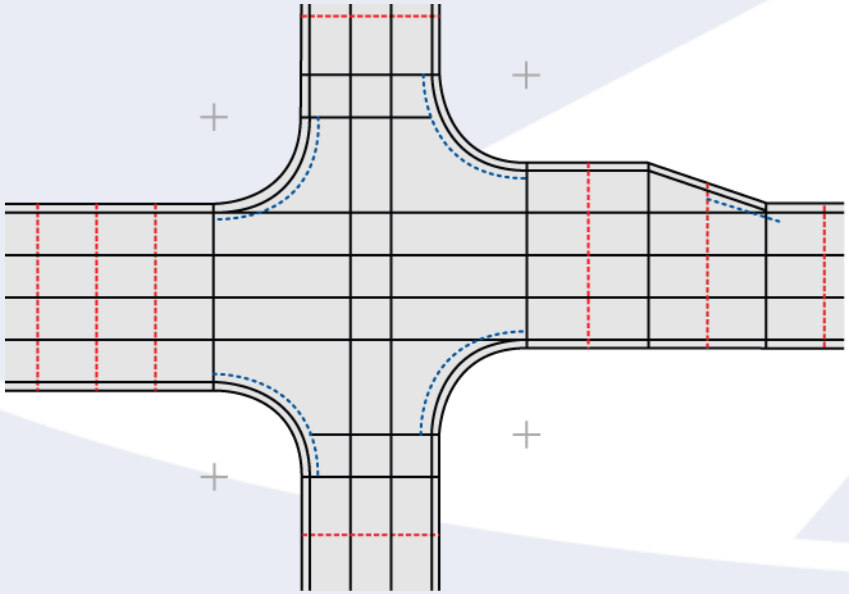


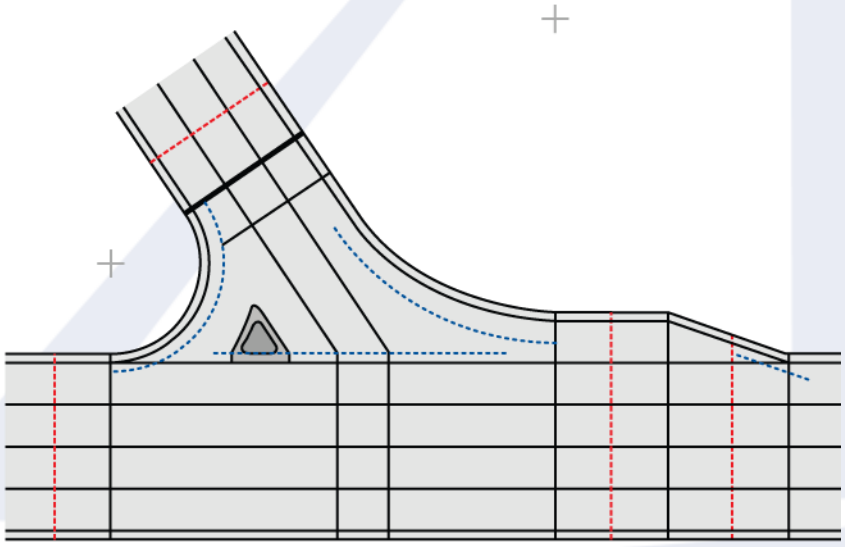


Concrete Intersections: Jointing

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}.

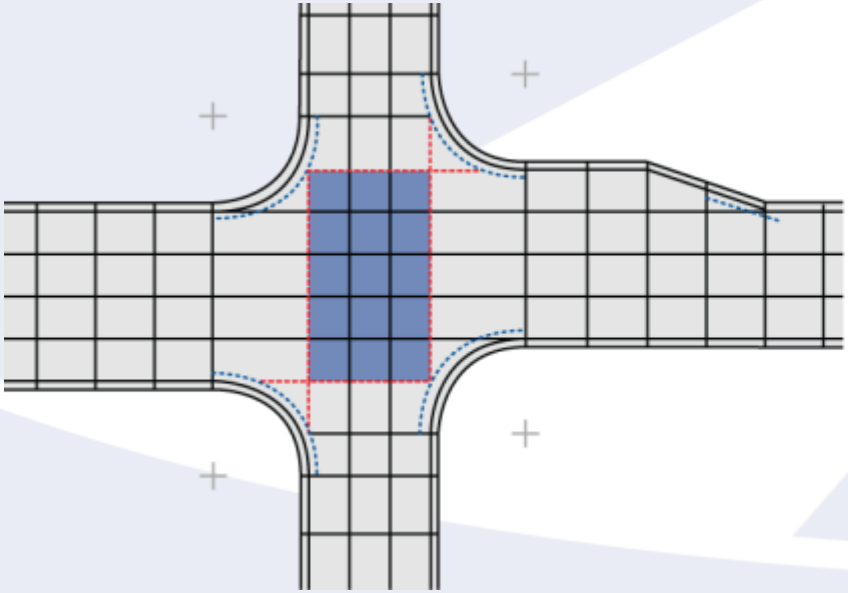


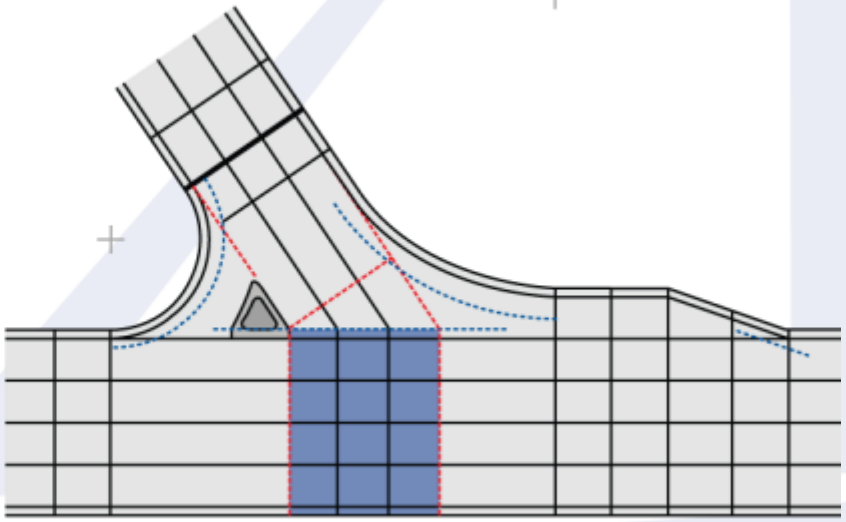


Concrete Intersections: Jointing

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.

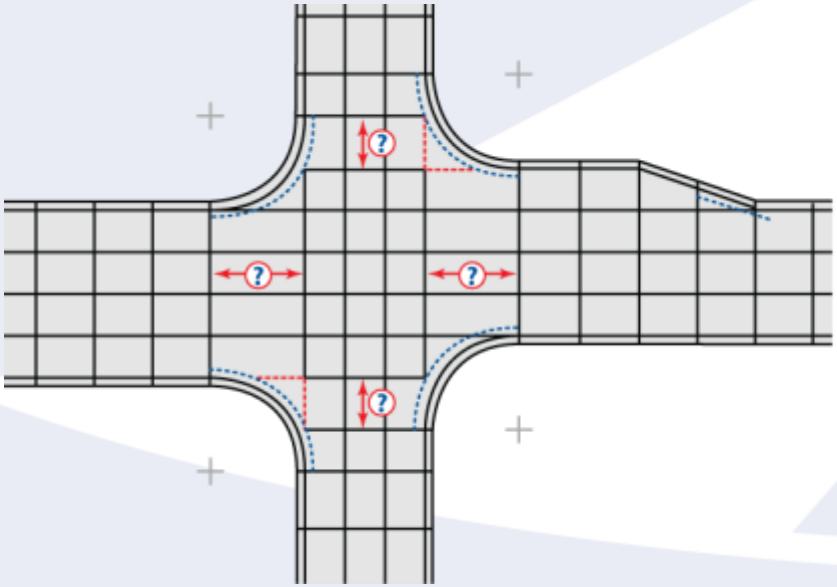


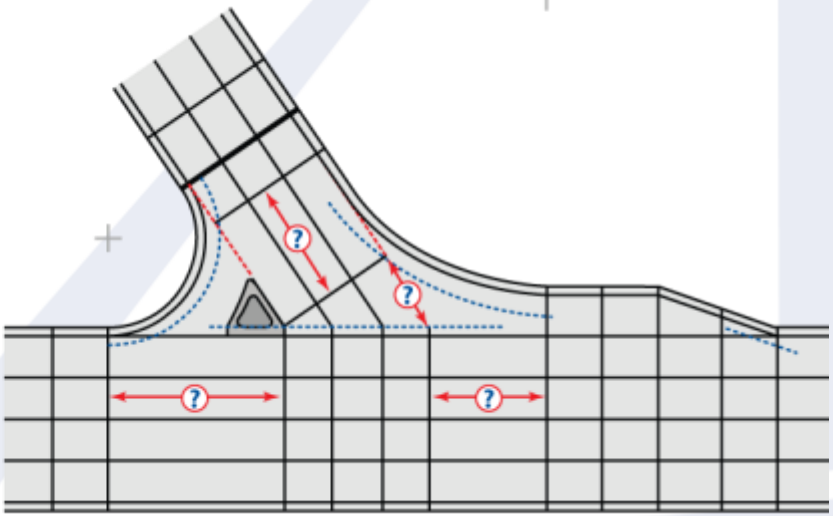


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

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

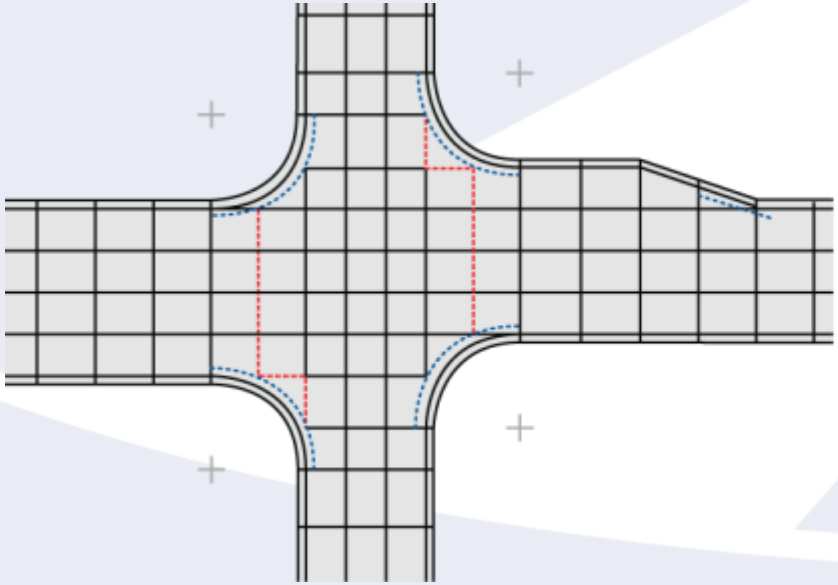


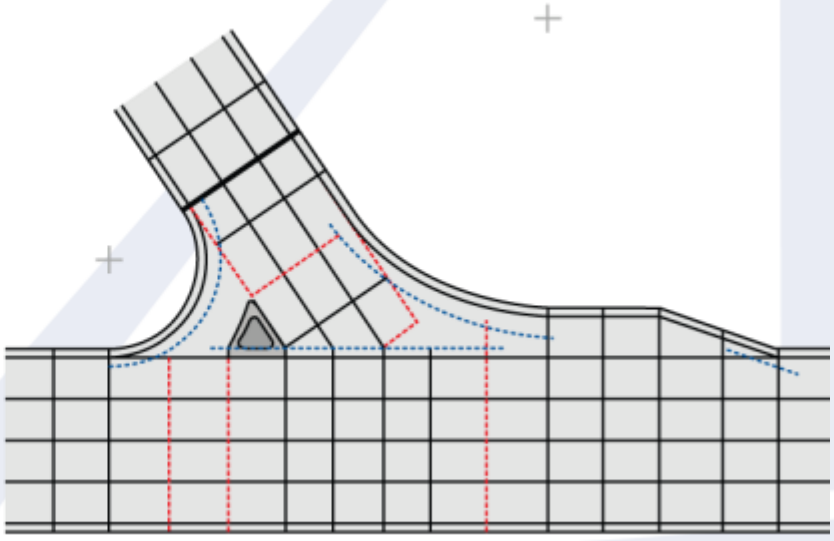


Concrete Intersections: Jointing

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.

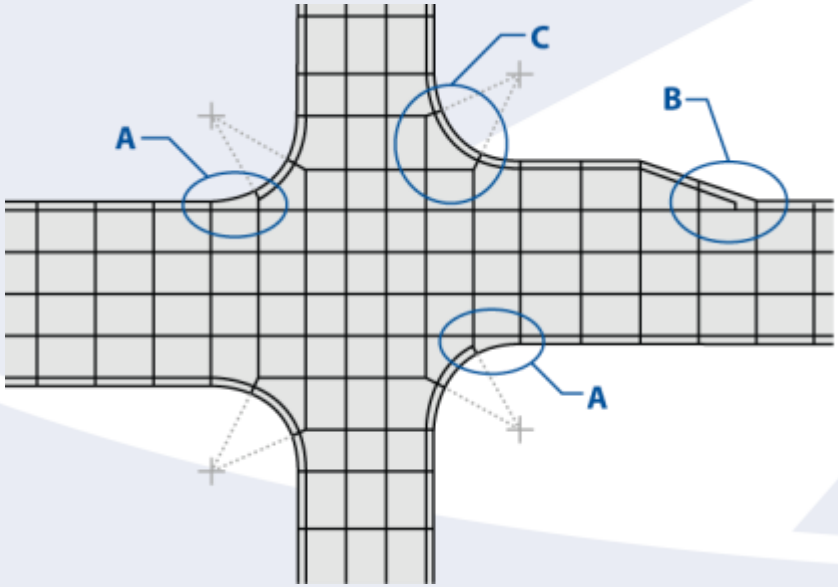


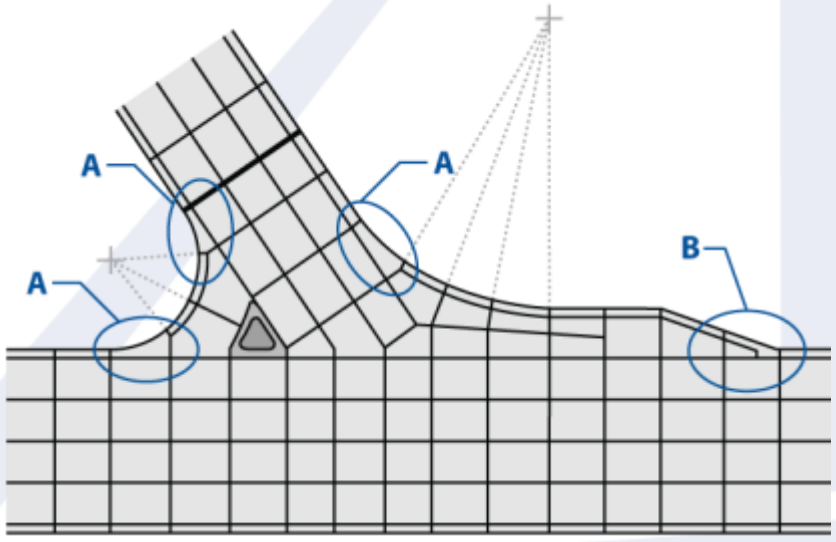


Concrete Intersections: Jointing

The Ten-Step Method for Intersections

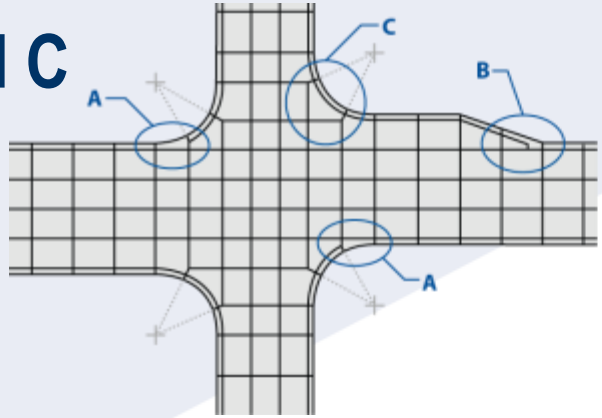
Step 10: Extend lines from center of curb return radii to corners of intersection box panels. Draw joints along these “diagonal” lines. Make adjustments to eliminate doglegs in pavement edges.

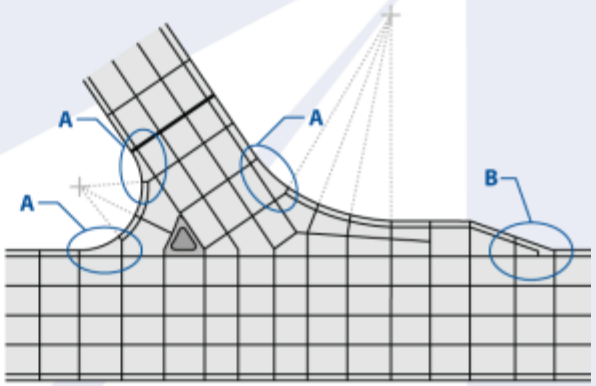


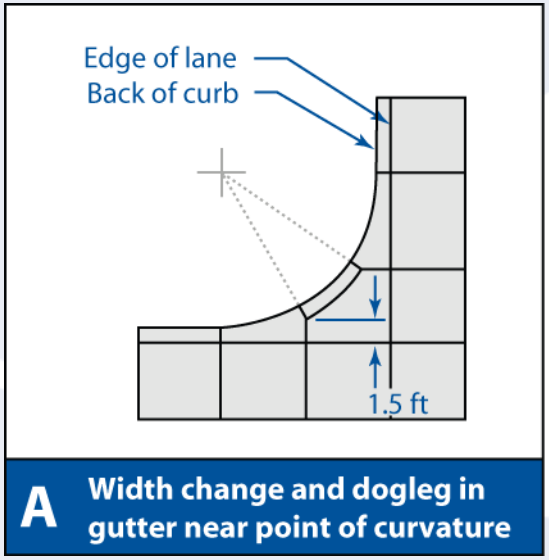


Concrete Intersections: Jointing

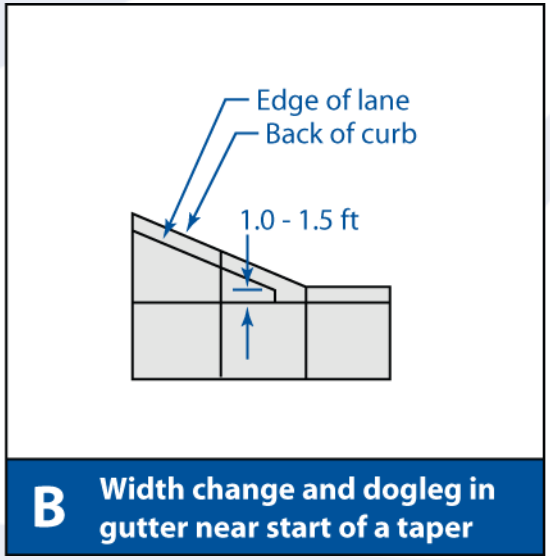
Details A, B, and C



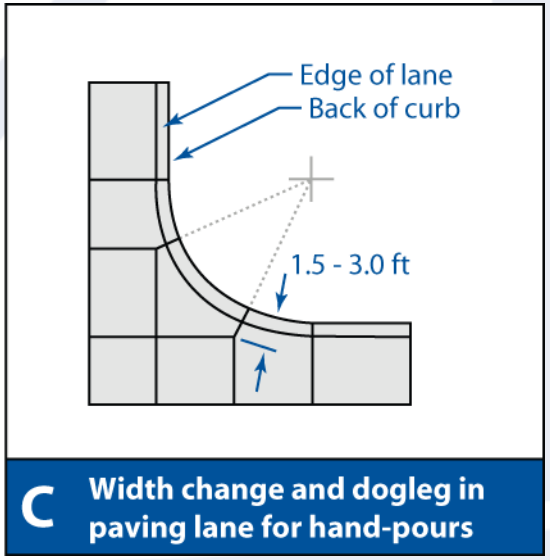




A Width change and dogleg in gutter near point of curvature

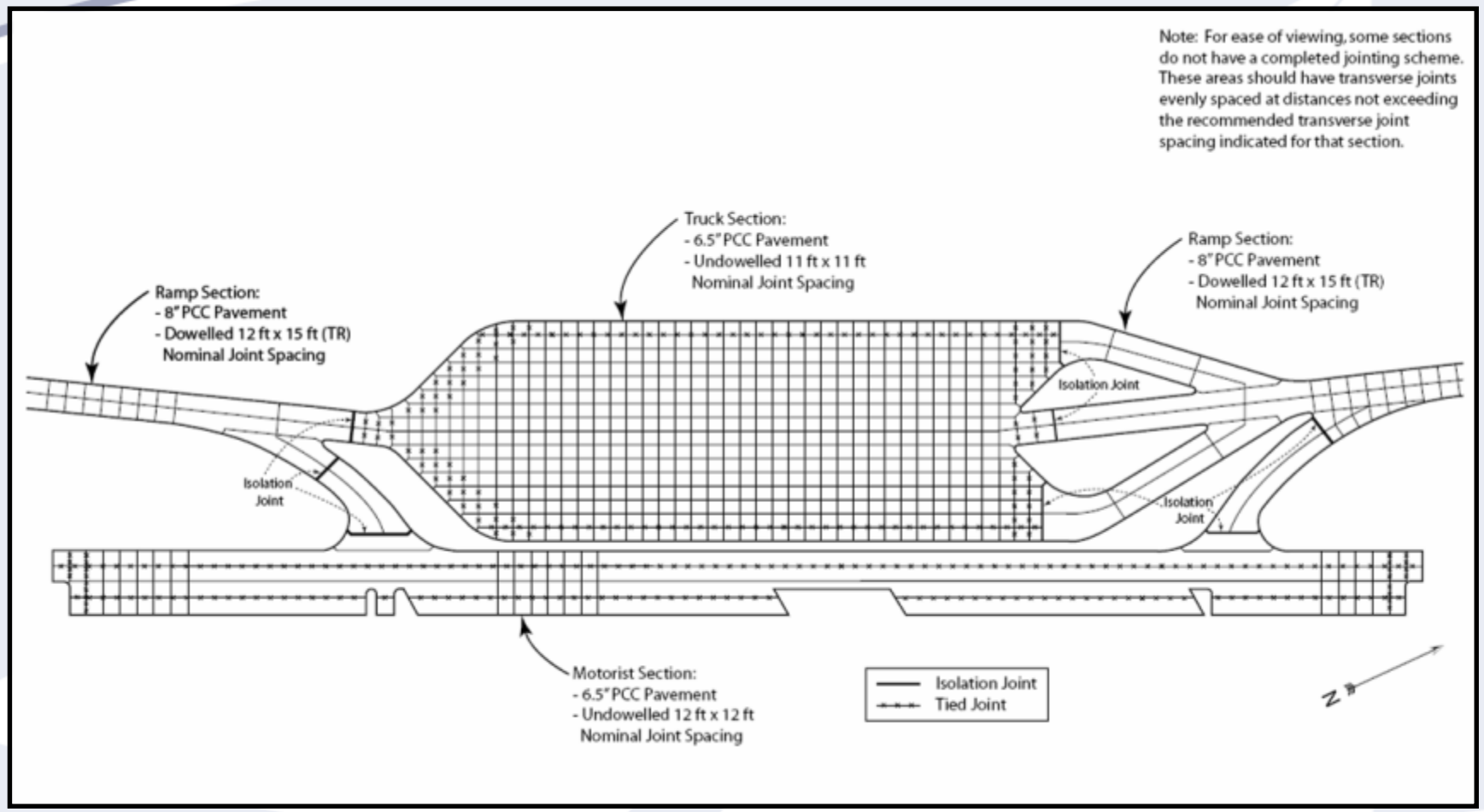


B Width change and dogleg in gutter near start of a taper

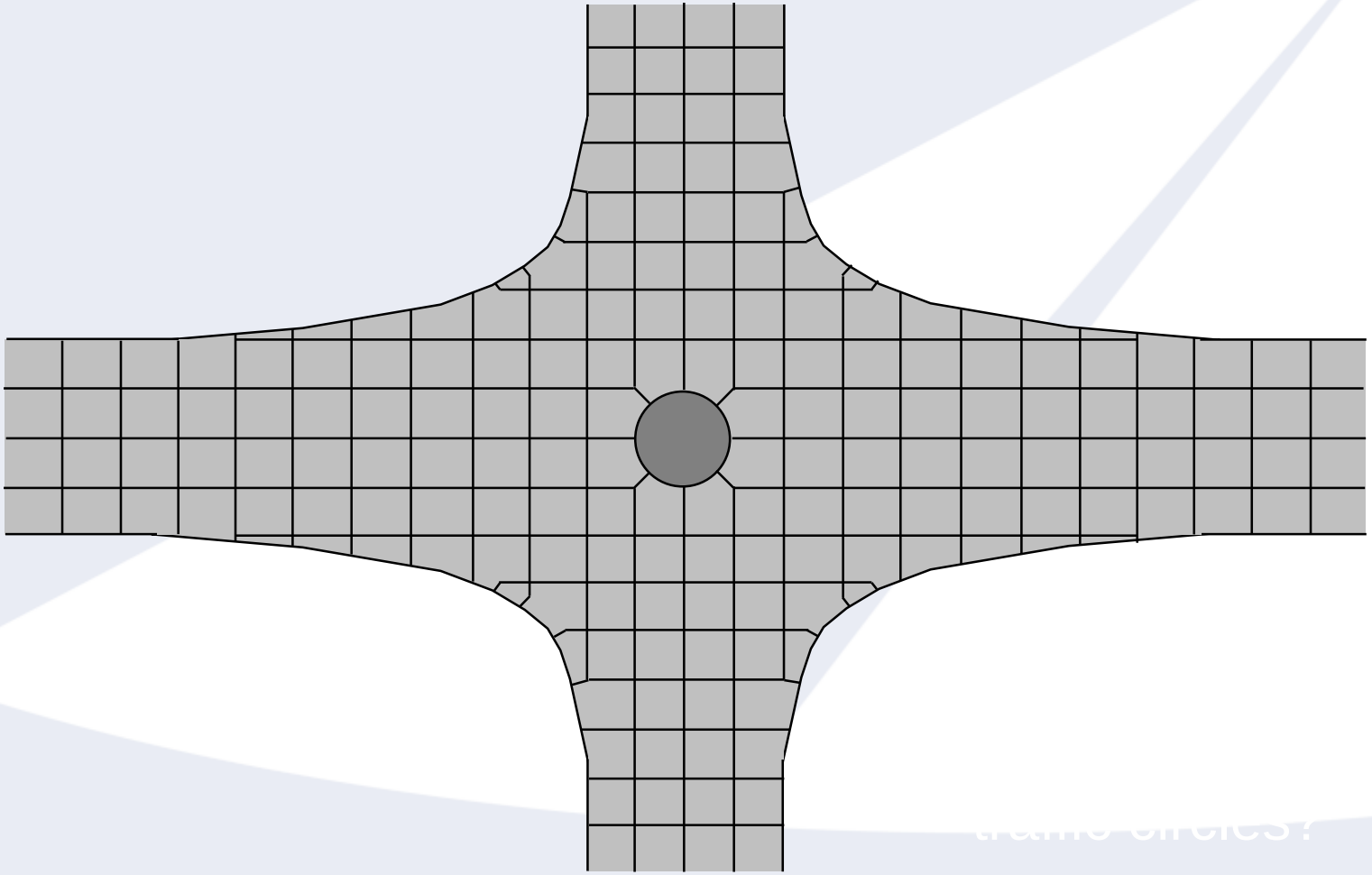


C Width change and dogleg in paving lane for hand-pours

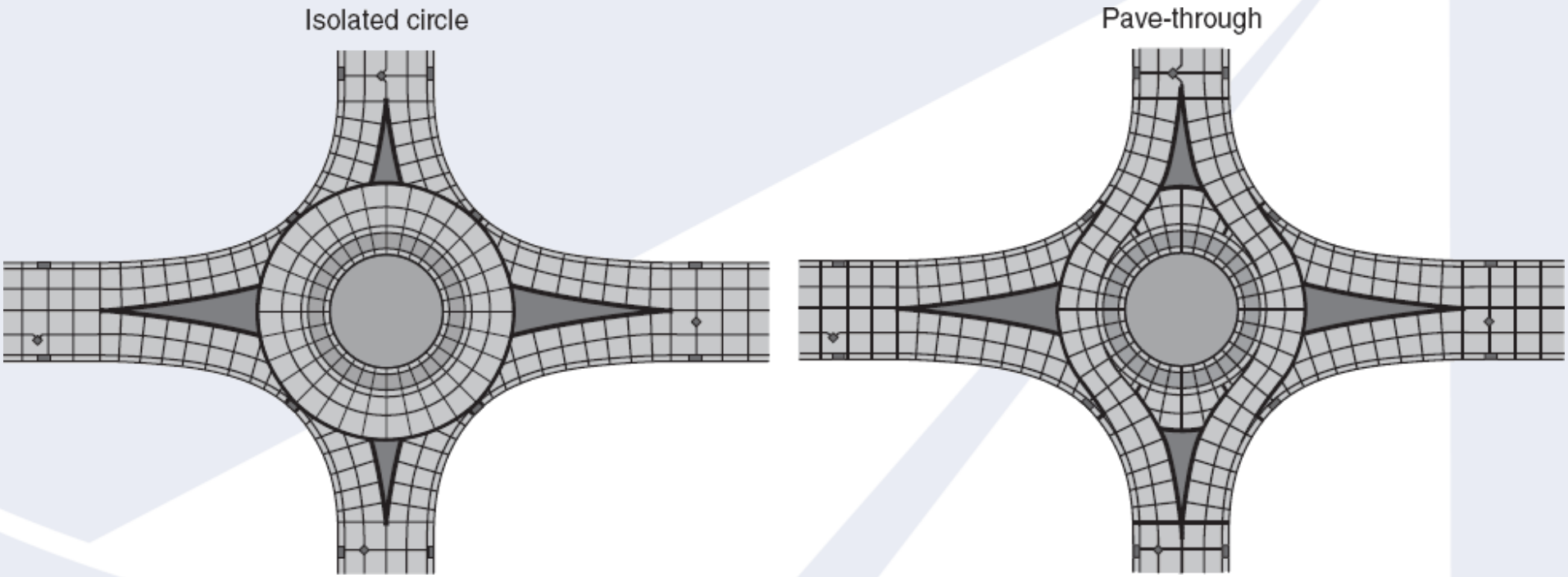
It works for other areas too.



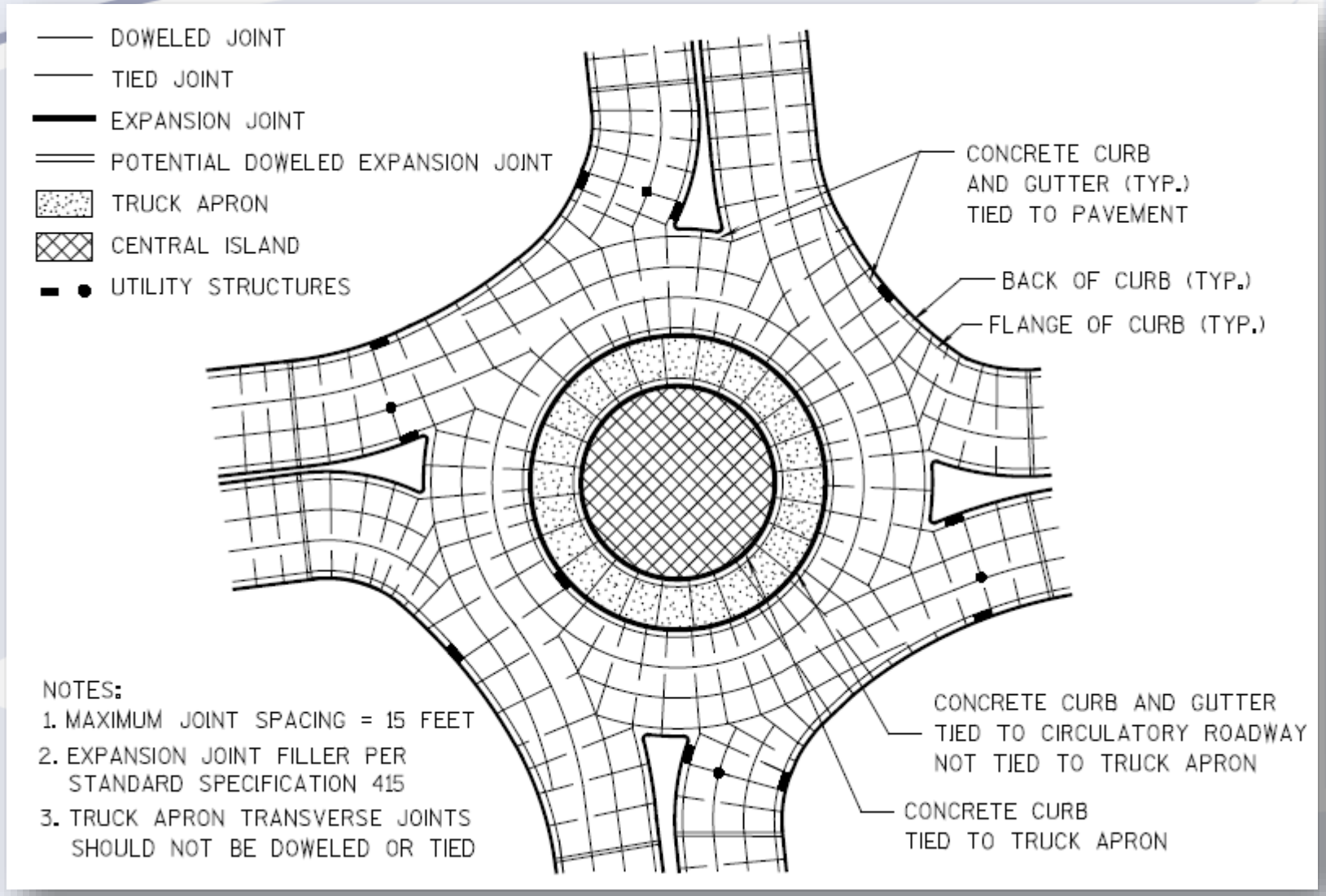
Roundabouts:
Lay Out Joints as Normal Intersection?



Proper Jointing of Roundabouts



What If I Have to Dead-end a Joint?

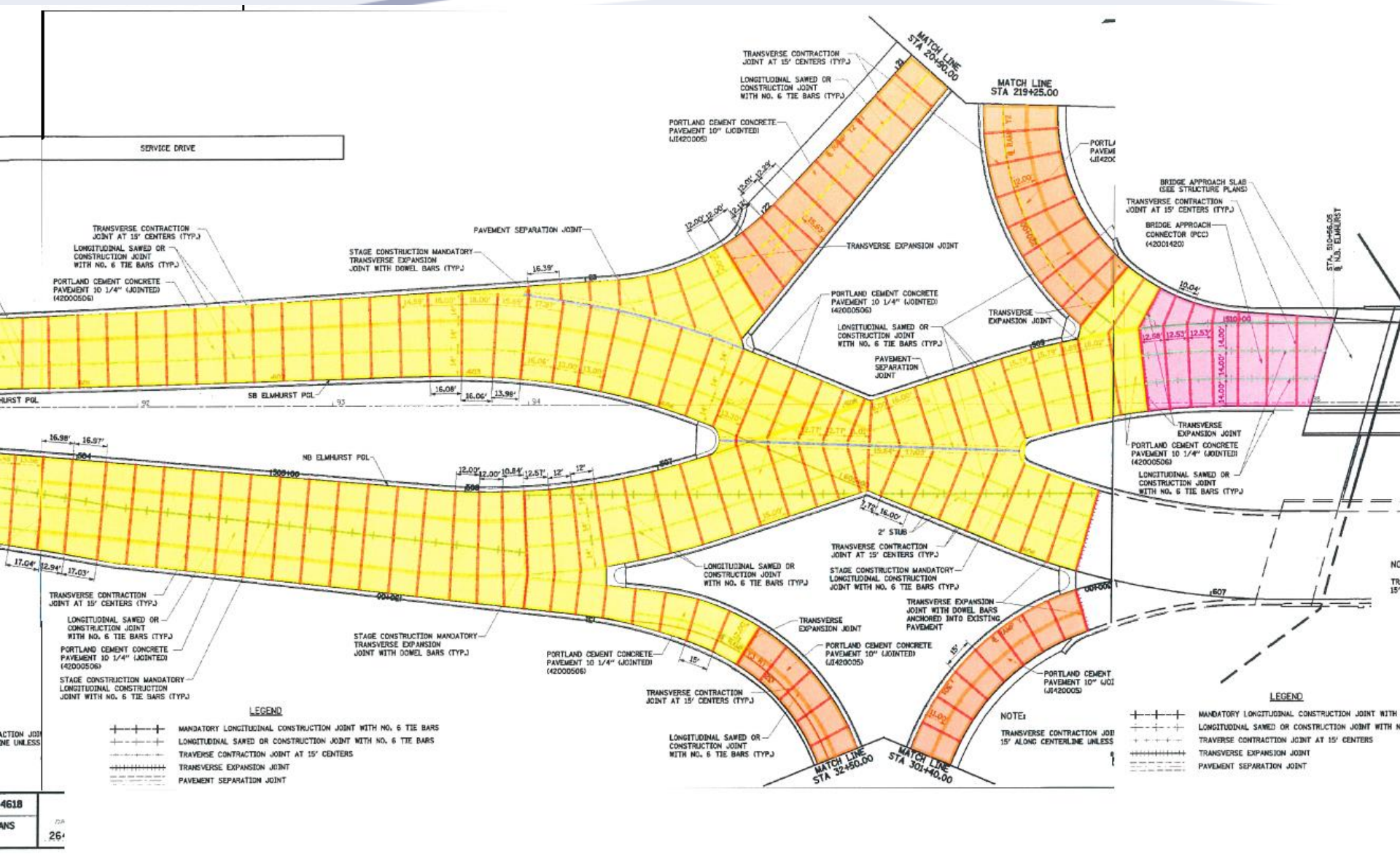


More Information?

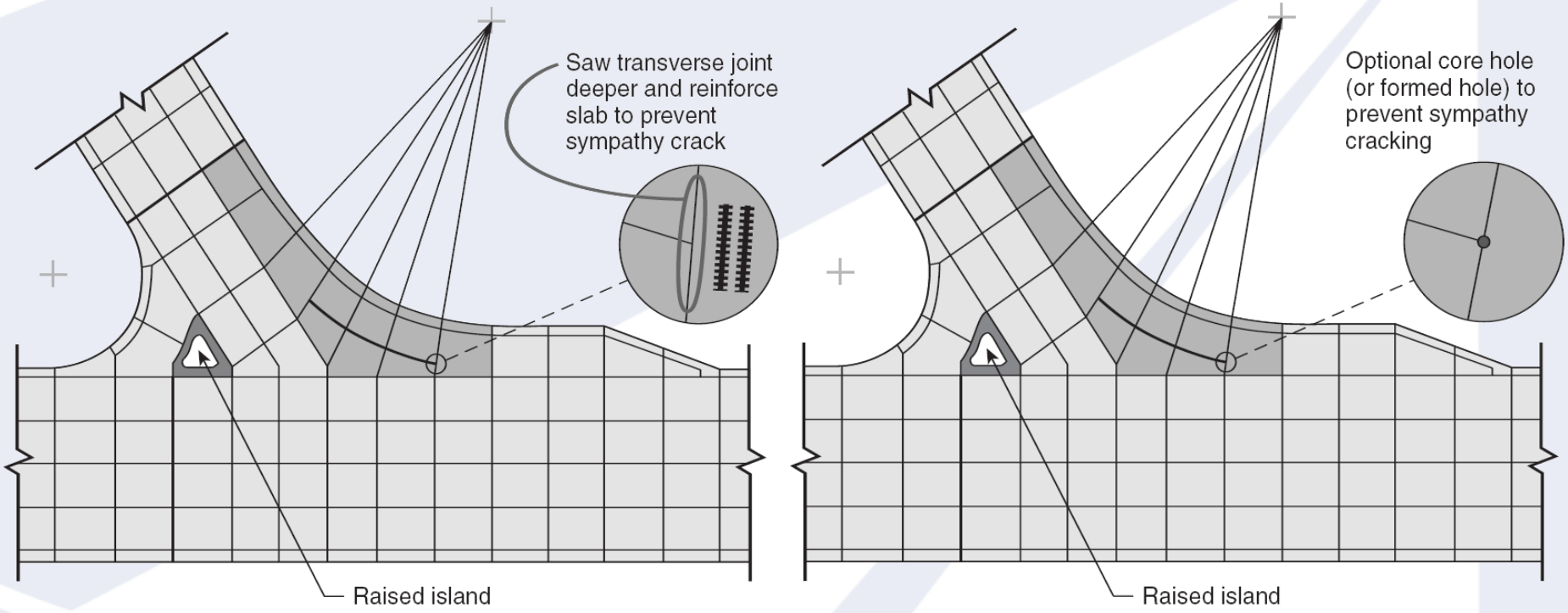
- “Concrete Pavement Field Reference: Prepaving,” EB237P, ACPA, 2007.
- “Concrete Roundabouts: Rigid Pavement Well-Suited to Increasingly Popular Intersection Type, “ R&T Update #6.03, ACPA, June 2005.
- “Roundabouts: An Informational Guide,” FHWA-RD-00-068, FHWA, March 2000.
- “Kansas Roundabout Guide”: http://www.ksdot.org/burTrafficEng/Roundabouts/Roundabout_Guide/RoundaboutGuide.asp
- Various agency standards…KS, WI, IA, OH, etc…

Diverging Diamond Interchanges

Jointing a DDI

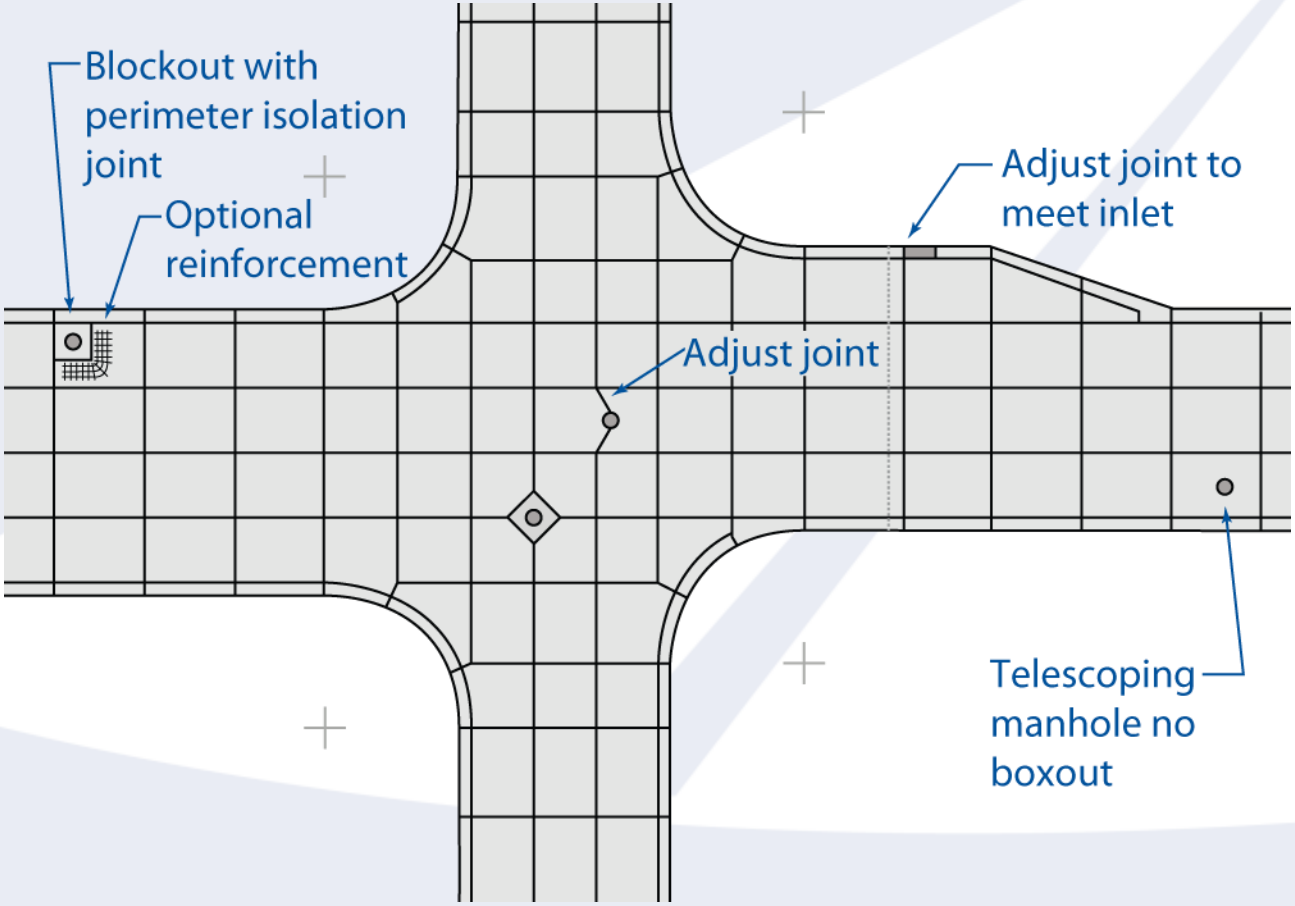


What If I Have to Dead-end a Joint?



Concrete Intersections: Jointing

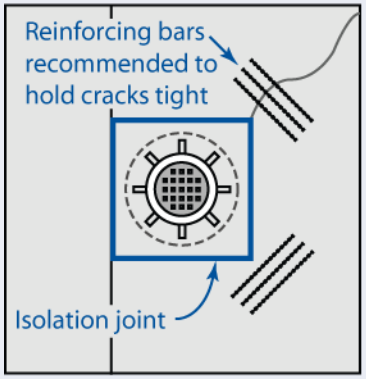
Adjust joints that are within 5 ft of a utility!



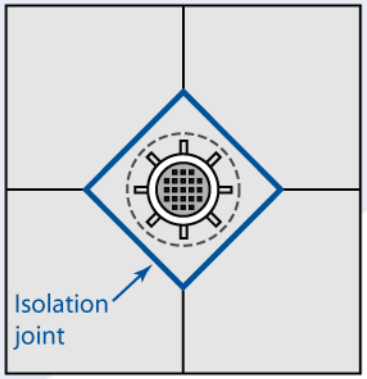
Concrete Intersections: Jointing

Box Out Fixture Details

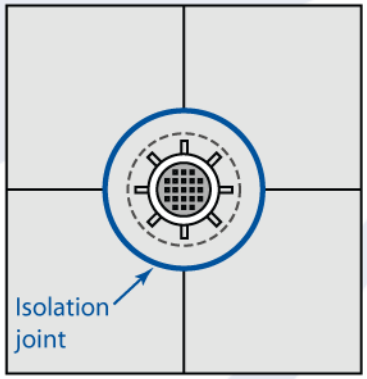
Square Manhole Boxout



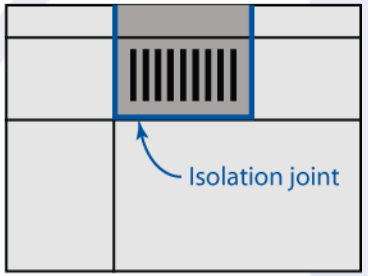
Diagonal Manhole Boxout



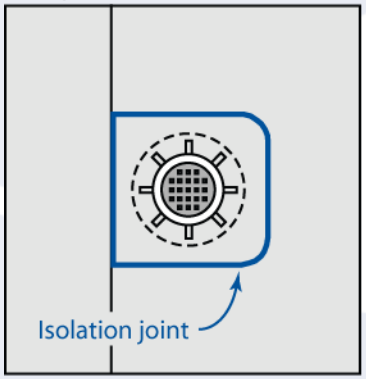
Circular Manhole Boxout



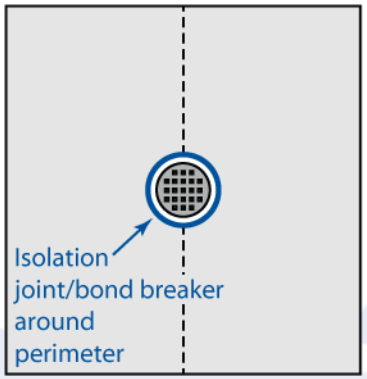
Square Inlet (no boxout)



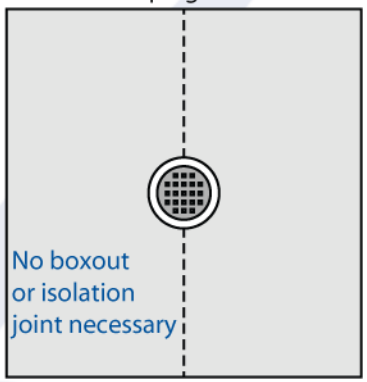
Square Boxout with Fillets



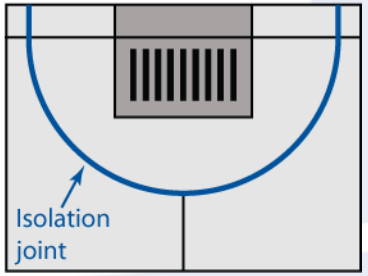
Manhole (No Boxout)



Telescoping Manhole



Round Inlet Boxout



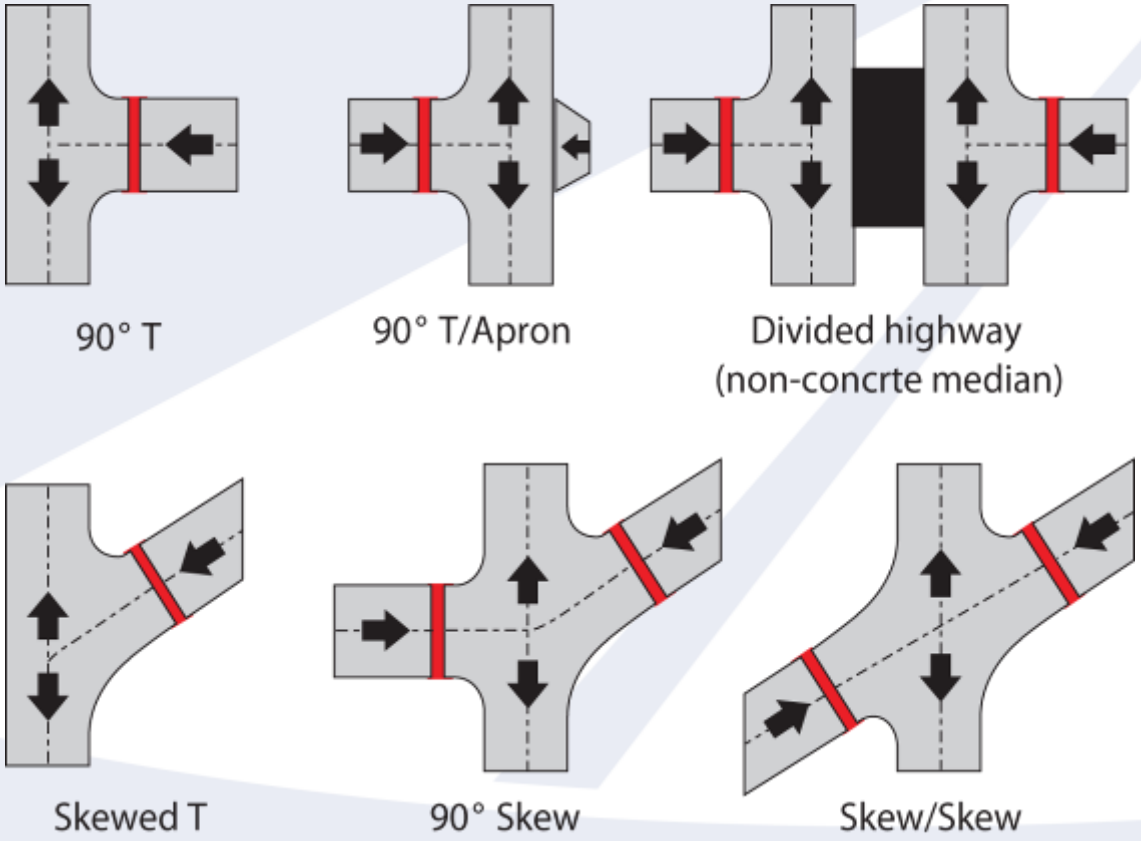
If You DO Box Out Properly…

If You DON'T Box Out Properly…

Good Practice...

Where to Place Isolation Joints

- Where do you put isolation joints?



Define Joint Type


CONCRETE PAVING Technology

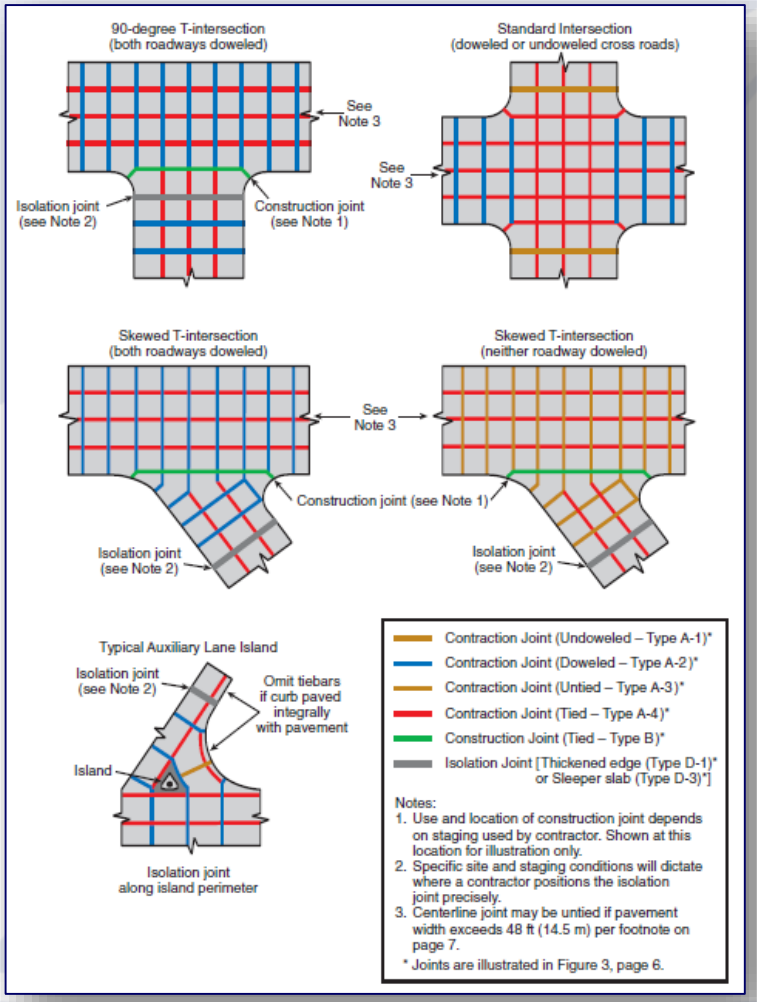
ACPA

Concrete Intersections

A Guide for Design and Construction

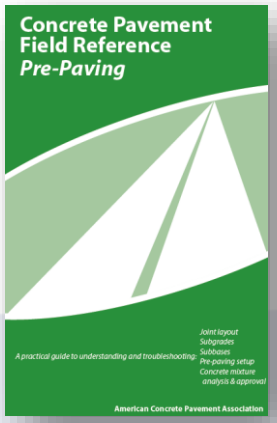
Introduction

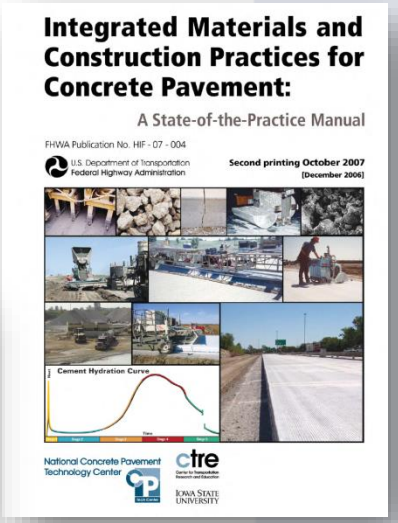
TB019P



Troubleshooting?

- Raveling or spalling is occurring due to sawing too soon or equipment problems.
- Early-age cracking is occurring due to sawing too late, insufficient joint depth, excessive joint spacing, excessive warping, excessive curling, too many lanes tied together, too much edge restraint, excessive slab/subbase bonding or restraint, misalignment of dowel bars, paving in cold weather, or paving in hot/dry weather.
- Sealant not adhering to joint.
- Sealant picks up or pulls out when opened to traffic.
- Sealant gelling in melting chamber (melter).
- Sealant cracking or debonding.
- Voids or bubbles in cured sealant.
- Etc…
- **… see ACPA literature or IMCP**





Thank You For Your Attention!