# Designing Concrete Pavements Best Practices

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# Design... for What?

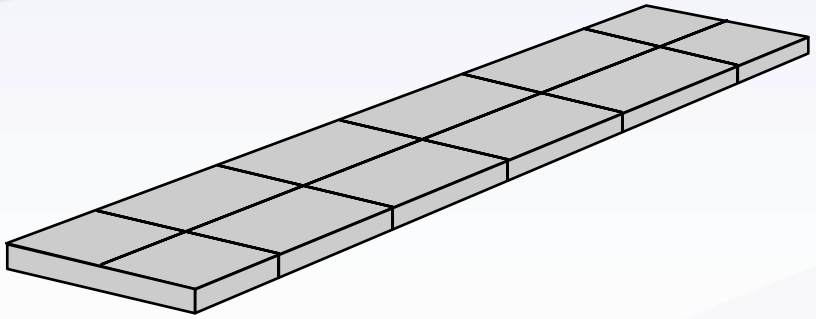
# Lots of design considerations…

- Geometrics
- Curb and Gutter
- Shoulder

# Lots of design considerations…

- Traffic
- Climate
- Drainage
- Etc.

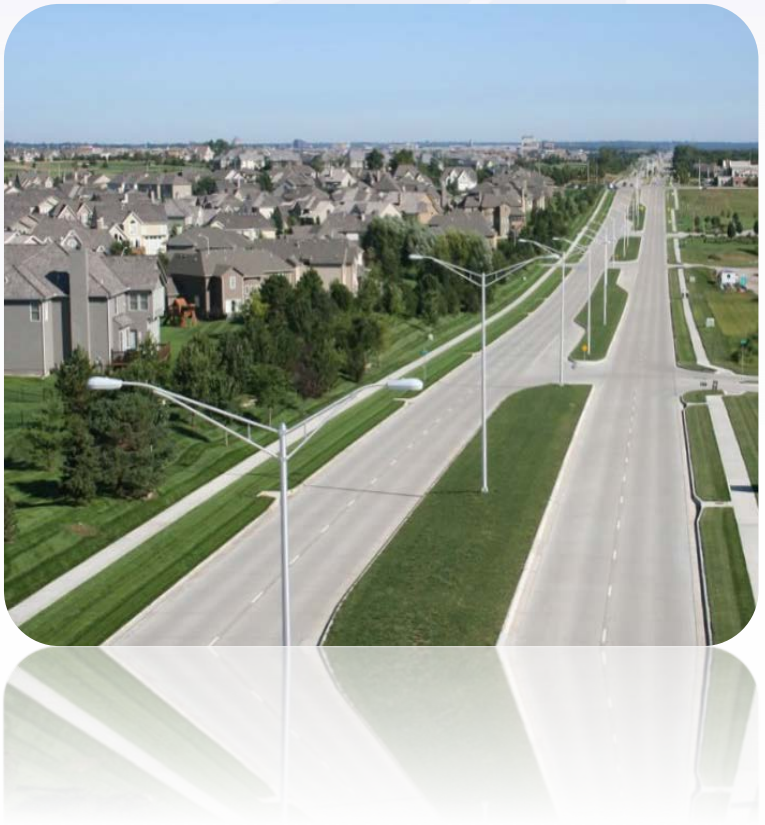
**Are consistent.**



# What Design Considerations are Concrete Specific?

# Concrete Pavement Specific Design Considerations

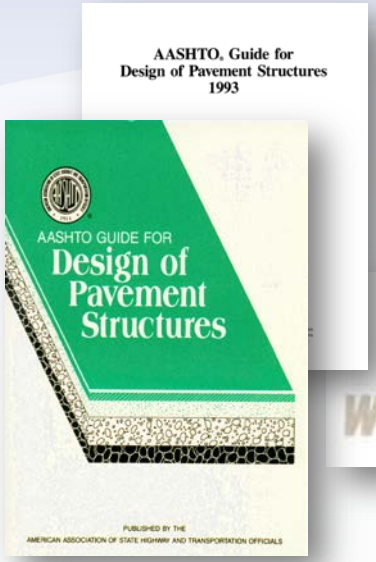
- Thickness Design
  - Design Programs/Guides
  - Structural Response and Support
- Jointing
  - Joint spacing
  - Joint Layout
  - Dowel & Tie Bar Design
- Materials / Mixture Design



# Concrete Pavement Specific Design Considerations

- Thickness Design
- Joint Design
- Materials / Mixture Design

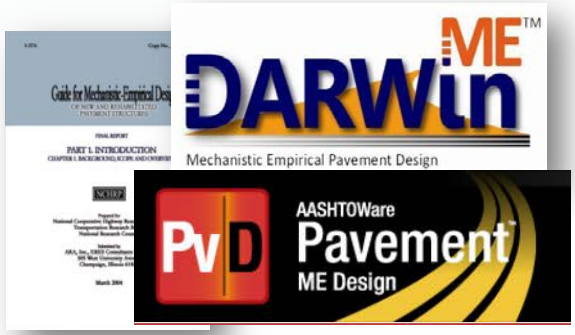
# Selecting a Pavement Design Tool




**AASHTO 93**
(software as
ACPA WinPAS)


**FREE**
**Industry**
**Developed**
**Method**

PavementDesigner.org




**AASHTOWare**
**Pavement ME**
(previously known as
DARWin-ME and
MEPDG)

# Selecting a Pavement Design Tool

*Outdated*


**AASHTO 93**
1962-1998
10 inputs
"Performance"
Field Data

THE 40 YEAR DIVIDE

*Current Design Tools*

**StreetPave**
2005-2017
12 inputs
Crack & Fault
**FEA** + Field Data

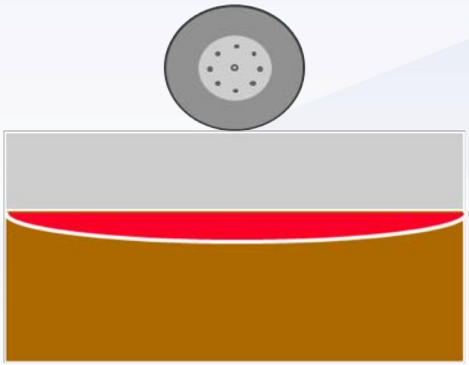
**PavementDesigner**
2018 - Present
12 inputs
Crack & Fault
**FEA** + Field Data

**Pavement ME**
2009 - Present
≈ 1,000 inputs
Crack, Fault, IRI
**FEA** + Field Data

**Increasing Complexity = More Accurate Models & More *Optimization* Options**

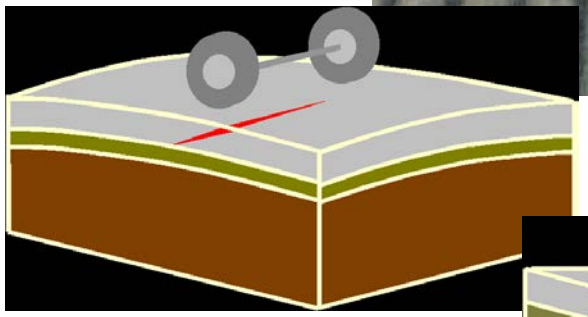
# Concrete Pavement Structural Response / Failure

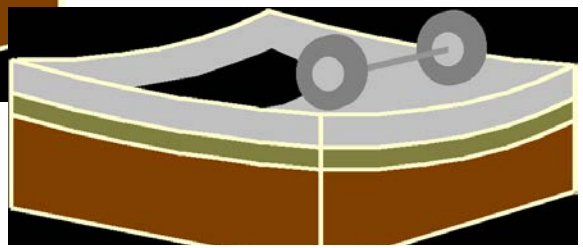
- Cracking
- Faulting
- Roughness (IRI)



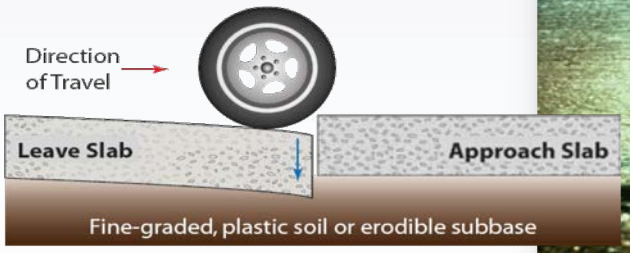
# What Impacts Cracking Performance?

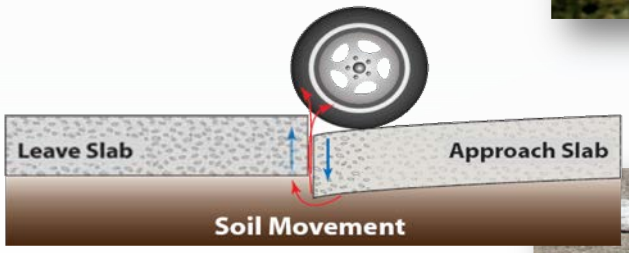
- Pavement Thickness
- Mix Design (Strength)
- Joint Spacing
- ~~Climate~~
- Lane Width
- Shoulder Design
- Support Stiffness





# What Impacts Faulting Performance?



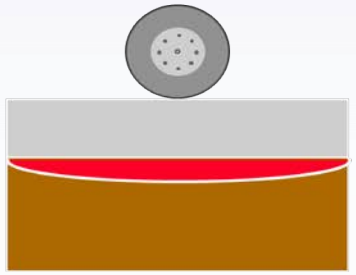

- Dowel Design
  - Size/Spacing
- Joint Spacing
- Lane Width
- Support System
  - Erodibility of Support
- Thickness (Inverse)

# Increasing Support System NOT Best Optimization

34,000 lbs.

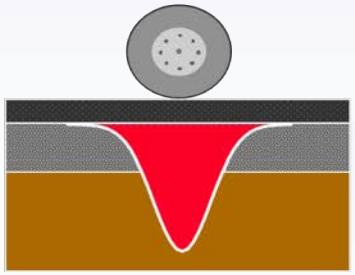
Load appliles
12,000 lbs. to
the subgrade.

pressure = 5 psi



Concrete ESAL
1.87

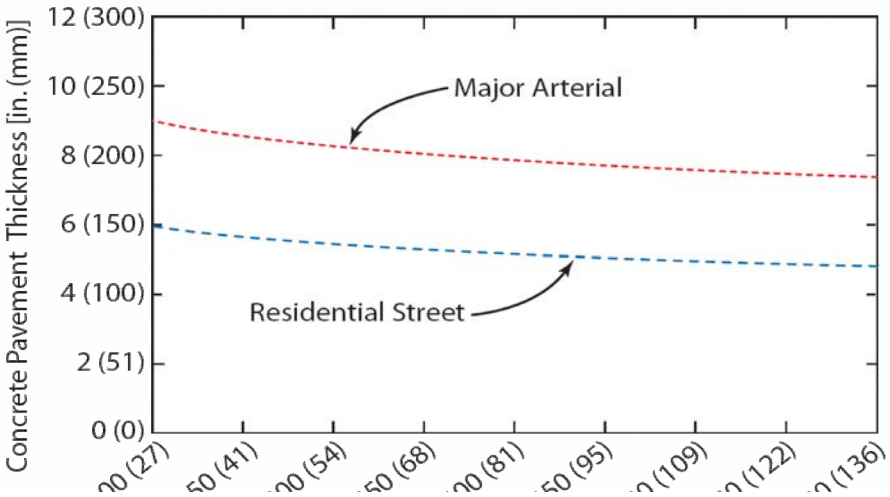
34,000 lbs.



Load appliles
24,000 lbs. to
the subgrade.

pressure = 30 psi

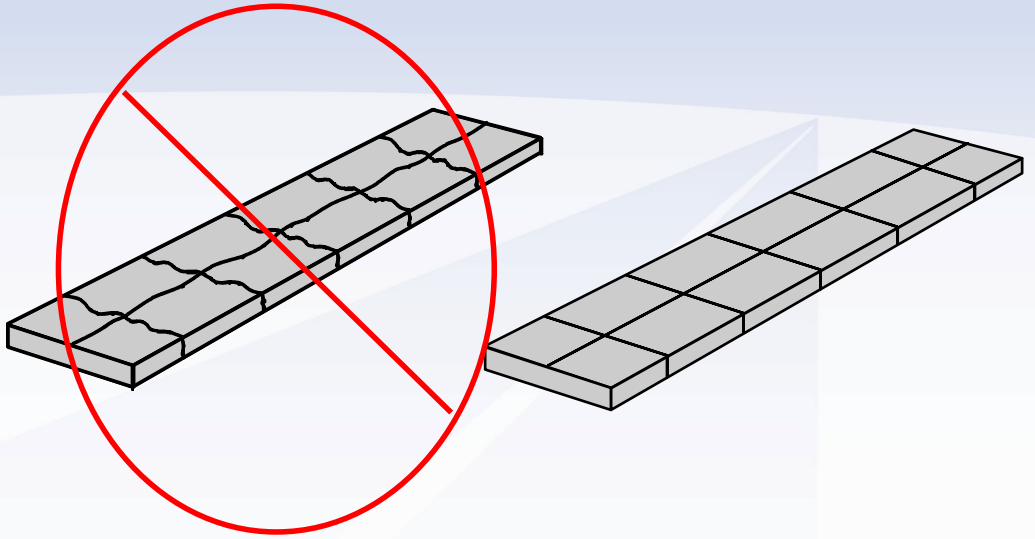
Bituminous ESAL
1.10



# Concrete Pavement Specific Design Considerations

- Thickness Design
- Joint Design
- Materials / Mixture Design

# Why Joint Concrete Pavement?



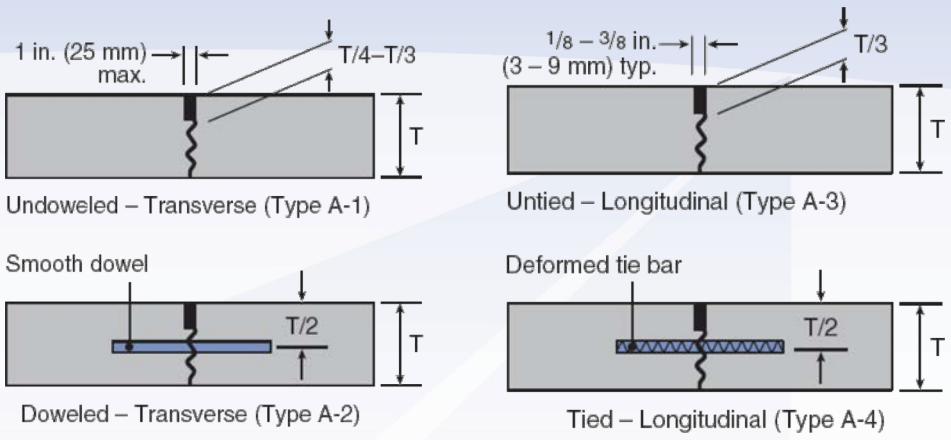
Other reasons we joint concrete pavements:

- **Control Cracking**
- **Divide pavement into construction lanes or increments.**
- Accommodate slab movements.
- **Provide load transfer via placed dowels**.
- Provide uniform sealant reservoir.

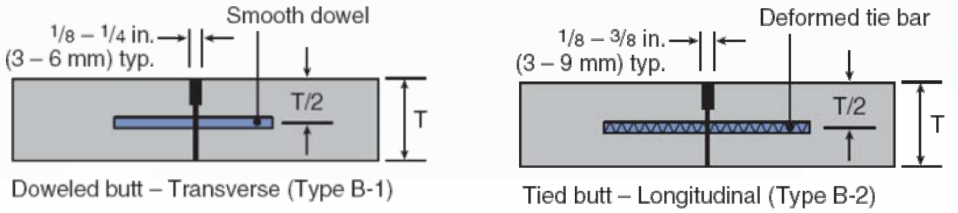
# Designing Joints

- Joint Spacing
- Joint types:
  - Contraction
  - Construction
  - Isolation (and, if necessary, expansion)
  - Transitions (PCC/AC)
- Load transfer and edge support
- Joint Layout

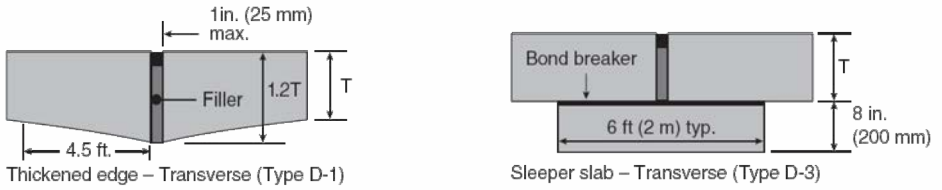
## Contraction




## Construction




## Isolation

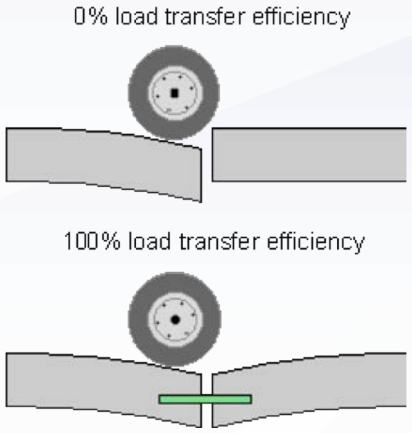


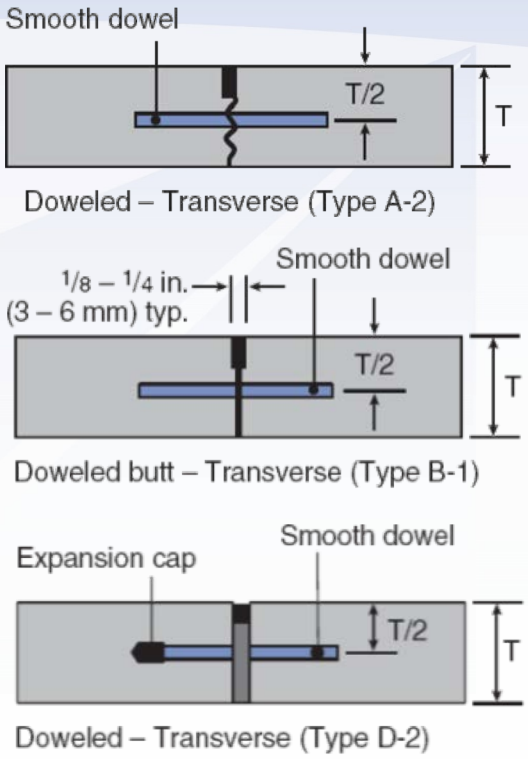
# Load Transfer / Maintaining Joint Continuity

- Aggregate Interlock
  - Maximum aggregate size……  ……is important!
- Mechanical connection
  - Dowel bars
  - Tie bars – NOT FOR LOAD TRANSFER
- Subbase support

# Joint Design – Dowel Bar Considerations

- Goals are:
  - Faulting resistance
  - Load transfer
- .Design for Load Transfer
  - Size
  - Spacing
  - Shape
  - Material

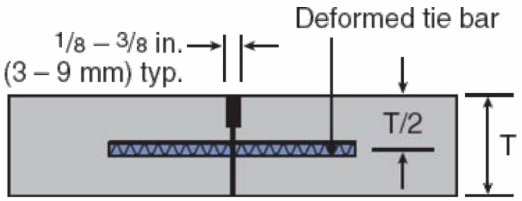


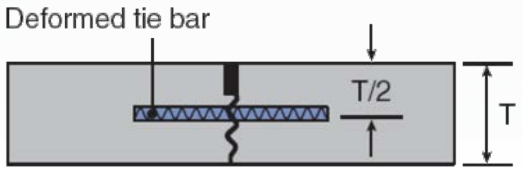

Dowel Design Tool:
http://www.acpa.org/dowelcad/

# Joint Design - Tiebar Considerations

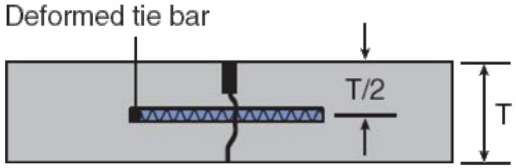
- Goals are:
  - Keeping joint tight
  - NOT FOR LOAD TRANSFER
- Design for Edge Support:
  - Size
  - Spacing
  - Embedment depth
  - Material



Tied butt – Longitudinal (Type B-2)



Tied – Longitudinal (Type A-4)

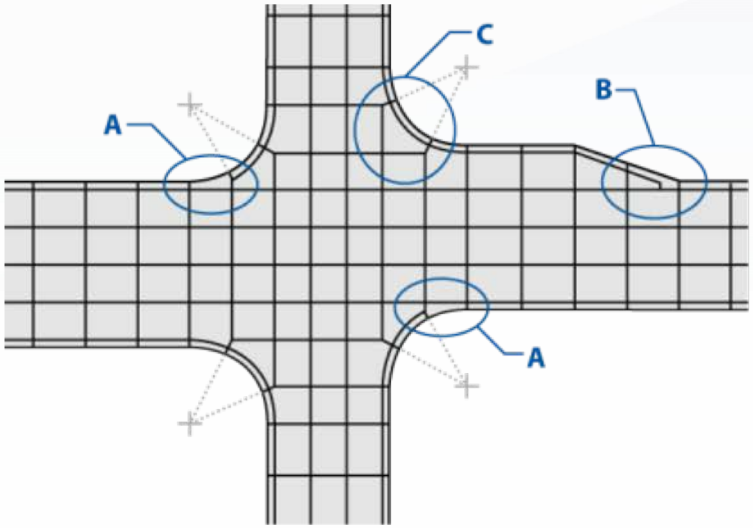


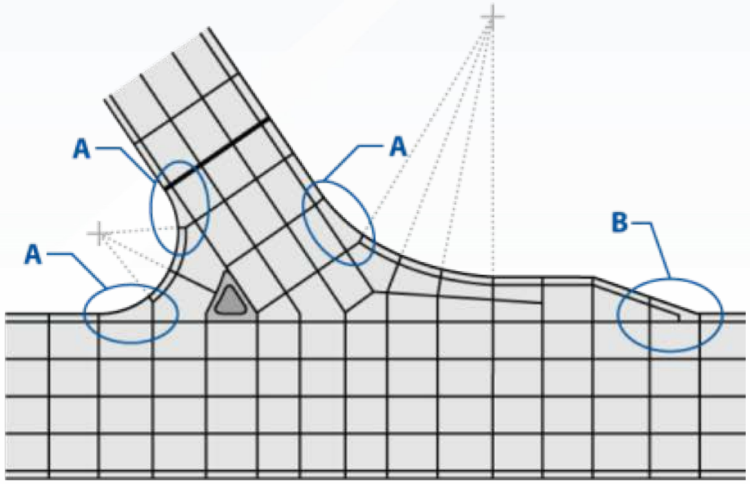
Tied – Transverse (Type C-1)
(Keyway optional)

# Joint Design – Layout for Complex Geometries

# Joint Layout – Intersections

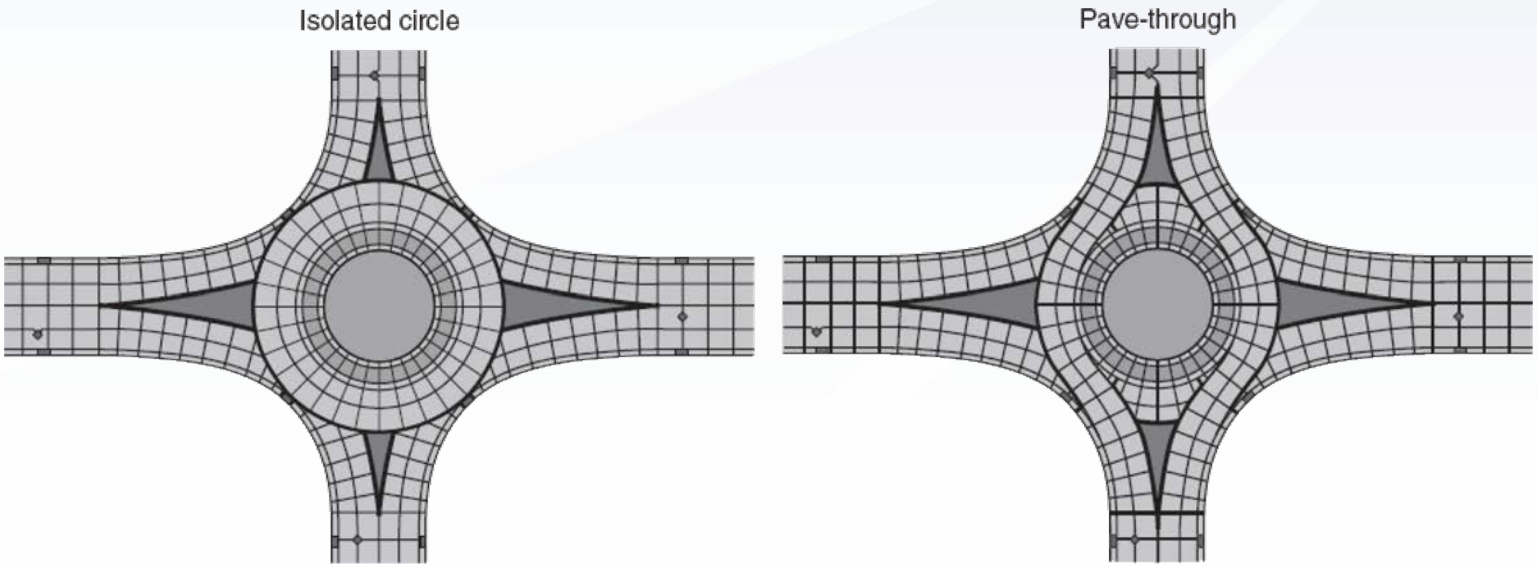
- 10 Step Method for Intersections



# Joint Layout – Roundabouts

- 6 Step Method for Roundabouts

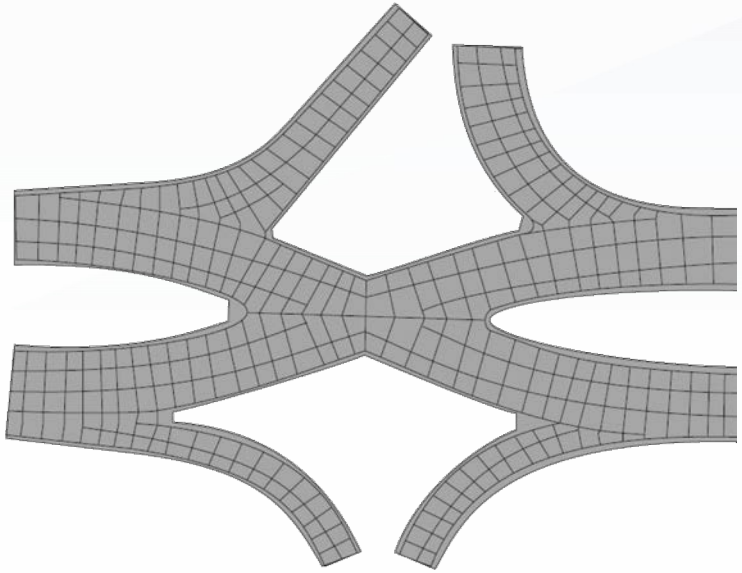



http://wikipave.org/index.php?title=Joint_Layout

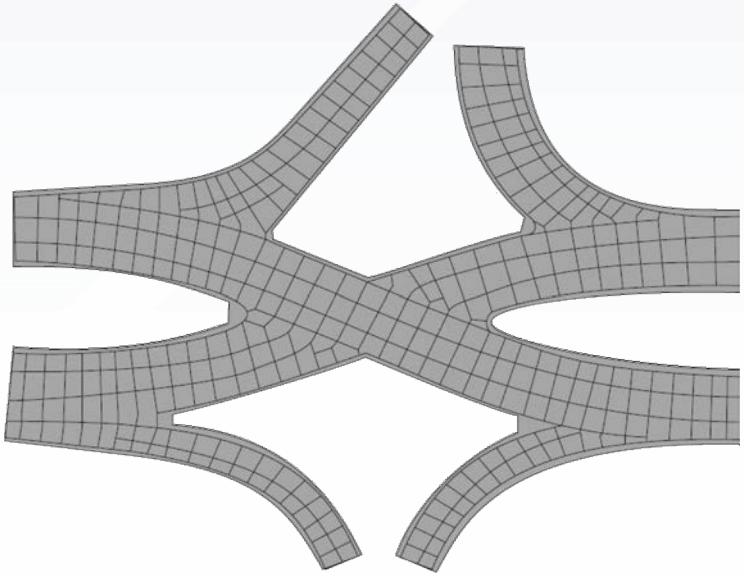
# Joint Layout – DDI

- 11 Step Method for Diverging Diamond Interchanges (DDI)

Quadrant Method



Pave-Through Method



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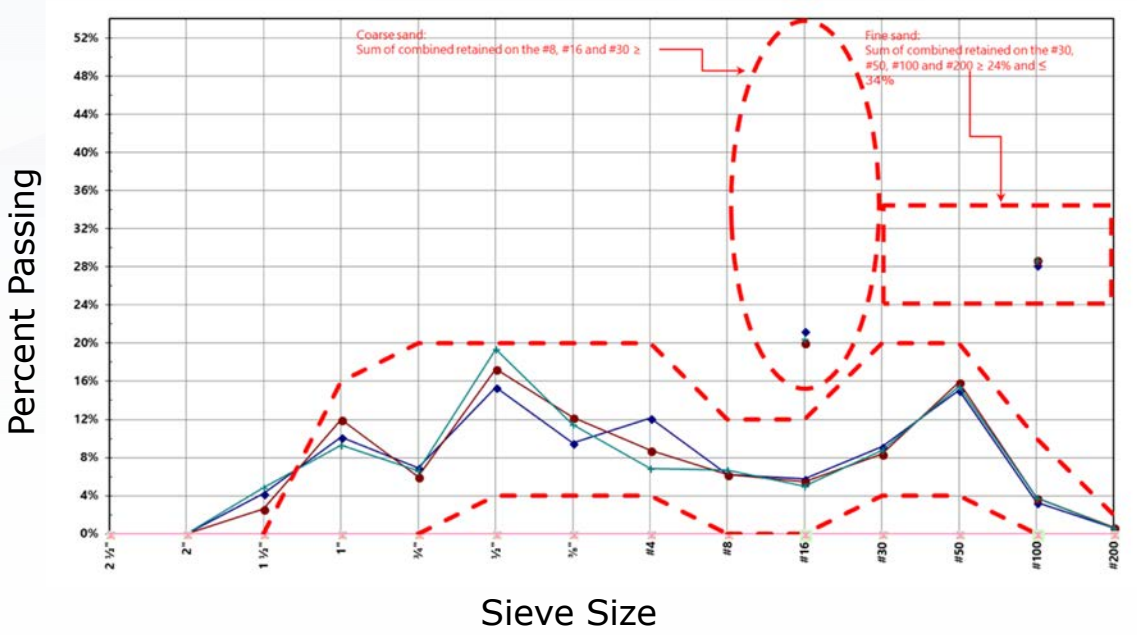
# Concrete Pavement Specific Design Considerations

- Thickness Design
- Joint Design
- Materials / Mixture Design

# Materials – Mixture Design

Performance Engineered Mixtures - https://cptechcenter.org/performance-engineered-mixtures-pem/

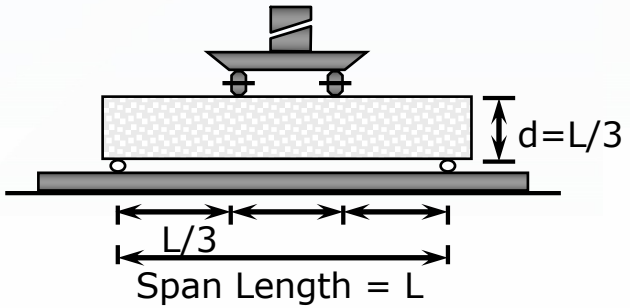
- Optimized gradation – Tarantula Curve / Shilstone Chart
- Reduced paste content – durability and shrinkage
- Minimize the use of accelerated mixtures
- Focus on project sequencing to accommodate maintenance of traffic
- Inclusion of Fibers?




Webinars and resources at https://cptechcenter.org/concrete-overlays/

# Mixture Design Considerations

- Structural design concerned with:
  - Strength (resistance to cracking)
    - Flexural (modulus of rupture)
    - Compressive (cube or cylinder)
  - Stiffness (resistance to deformation)
    - Modulus of elasticity (E)
  - Property altering additions
    - Fibers
    - Chemical admixtures
    - Mineral admixtures (SCMs)




*Focus in design is hardened properties such as strength and stiffness. Many of the chemical and mineral admixtures also alter fresh concrete properties.*

# Mixture Design Considerations

- Goals are:
  - Uniformity and consistency
  - Workability until placed
  - Ability to be consolidated
  - Ability to hold edge if slipforming
  - Finishability
  - Required strength/stiffness
  - Durability

# Summary

- Many design considerations are the same
- Concrete specific design considerations:
  - Thickness Design
    - Same tools as asphalt, but different approaches!
    - Can’t just increase thickness
  - Joint Design
    - Spacing matters!
    - Must design for load transfer
    - Layout for complex geometries is critical
  - Materials / Mix Design
    - Must meet design AND construction requirements

# Thank You!

Any Questions?

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