Concrete Issues

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Collaboration. Commitment. Confidence.℠

“There are no problems, only solutions…”

John Lennon

Issues Identified

- Flexural strength
- Bridge deck cracking
- Shrinkage
- Durability
- Concrete pavements in an urban environment

Flexural Strength Issues

- Nationally, it is common to achieve concrete flexural strengths in excess of 700 psi with 500 lbs/yd^3 or less total cementitious
  - Accomplished through optimized gradations in which three or more aggregates blended
  - TX, IL, MI, CA, UT are examples
- Such flexural strengths are achievable in Southern NV but difficult to achieve in the North

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On Average (Recent Projects)

Parameter	Northern NV	Southern NV	Percent Difference
Cementitious Content	698 lbs/yd3	642 lbs/yd3	+ 8.0%
w/cm	0.39	0.41	-5.0%
7-day Flexural Strength	583 psi	566 psi	+2.9%
28-day Flexural Strength	665 psi	779 psi	-17.1%
7-day Compressive Strength	4066 psi	4102 psi	-0.1%
28-day Compressive Strength	5309 psi	5996 psi	-12.9%

Note that most Southern NV mixtures are air entrained as are all of the mixtures in Northern NV

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As Delivered
After Washing

Flexural Strength Issues

- High cementitious contents needed to obtain desired strength
  - 658 lbs or more cementitious results in less durability, higher shrinkage, and poor economy
- Preliminary investigations underway to:
  - Identify the cause(s) of the problem
  - Develop cost effective solutions

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Bridge Deck Cracking

- High-performance concrete (HPC) bridge decks possess properties designed to extend life
  - Higher strength
  - Lower permeability
- Unfortunately, HPC typically has higher shrinkage and is more brittle than conventional concrete
- This results in increased tendency for uncontrolled early-age restraint cracking

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NDOT Practice

- Currently, NDOT employs Special Provisions on a project by project basis for bridge decks
  - Trends are towards reduced cementitious content (minimum total cementitious as low as 564 lbs/yd^3
  - Optimized aggregate grading
  - Increased use of SCMs
  - Additional testing including stiffness and rapid chloride permeability testing
  - Ten days of wet curing


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Mitigation Strategies

- Improved concrete mixtures
  - Reduced cementitious content
  - Shrinkage reducing admixtures
  - Internal curing using saturated lightweight aggregate
  - Macro synthetic fibers
- Extended wet curing
  - Limited effectiveness as *w/cm* drops and/or silica fume is used
- Corrosion inhibitors or corrosion resistant reinforcement
- NDOT has initiated a study to investigate options

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Issue: Drying Shrinkage

- Loss of mixing water over time due primarily to evaporation from exposed surfaces
  - Volume contracts
  - Greater paste content results in greater drying shrinkage and higher tensile stress when restrained
  - Initiates once surface dries
- For slabs, shrinkage occurs at surface
  - Bottom remains near or at saturation
- Shrinkage influenced by capillary porosity

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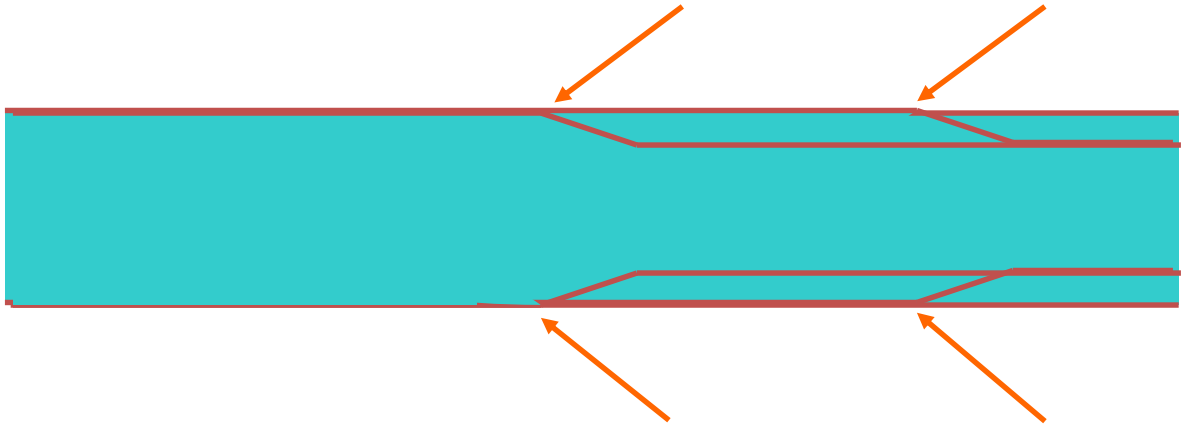
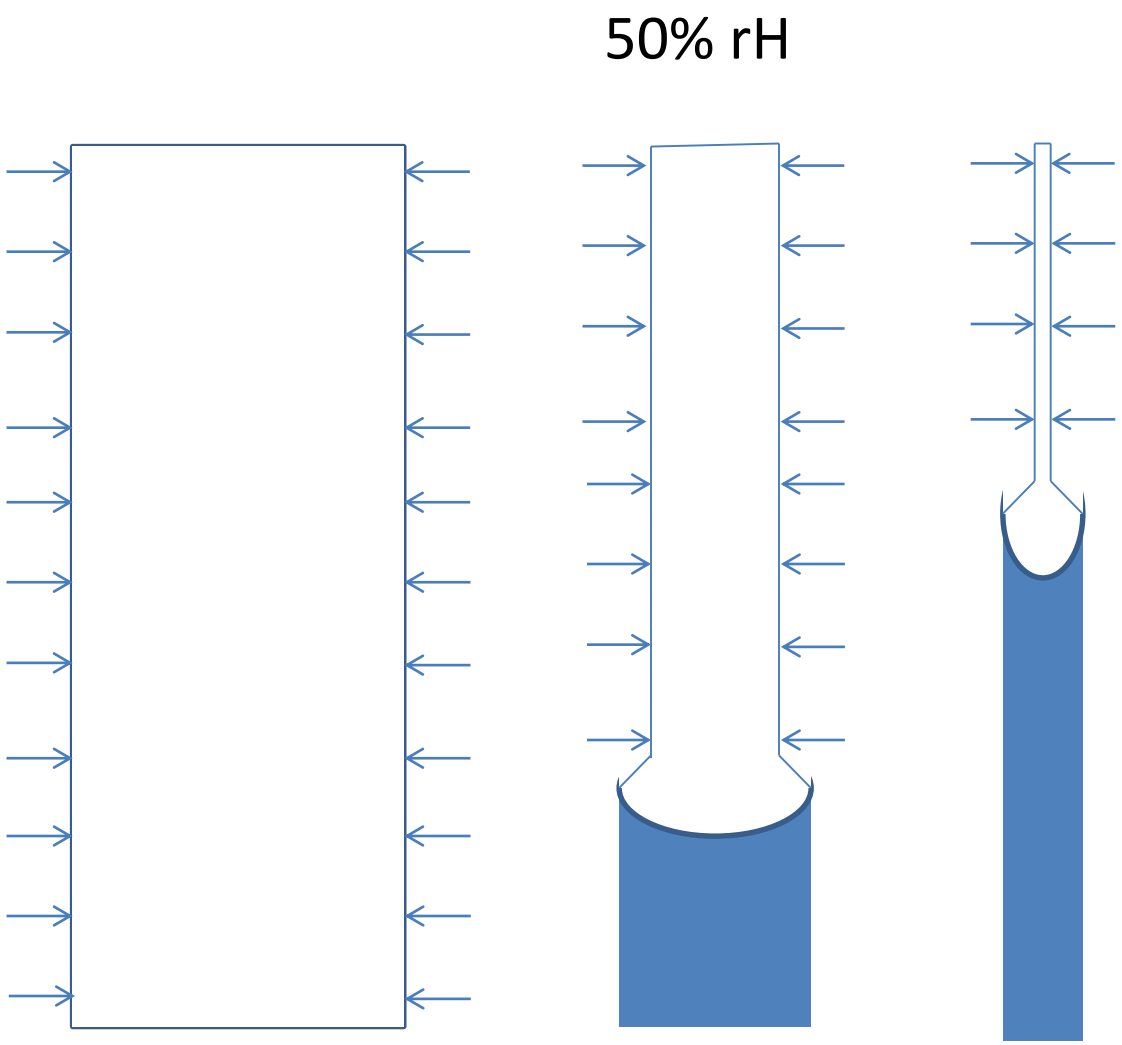
Capillary Pores

- Volume related to volume of mix water
- Influences permeability and strength
- Vary in size from 0.01 µm to 5 µm
- Menisci pull against void walls at air/water interface

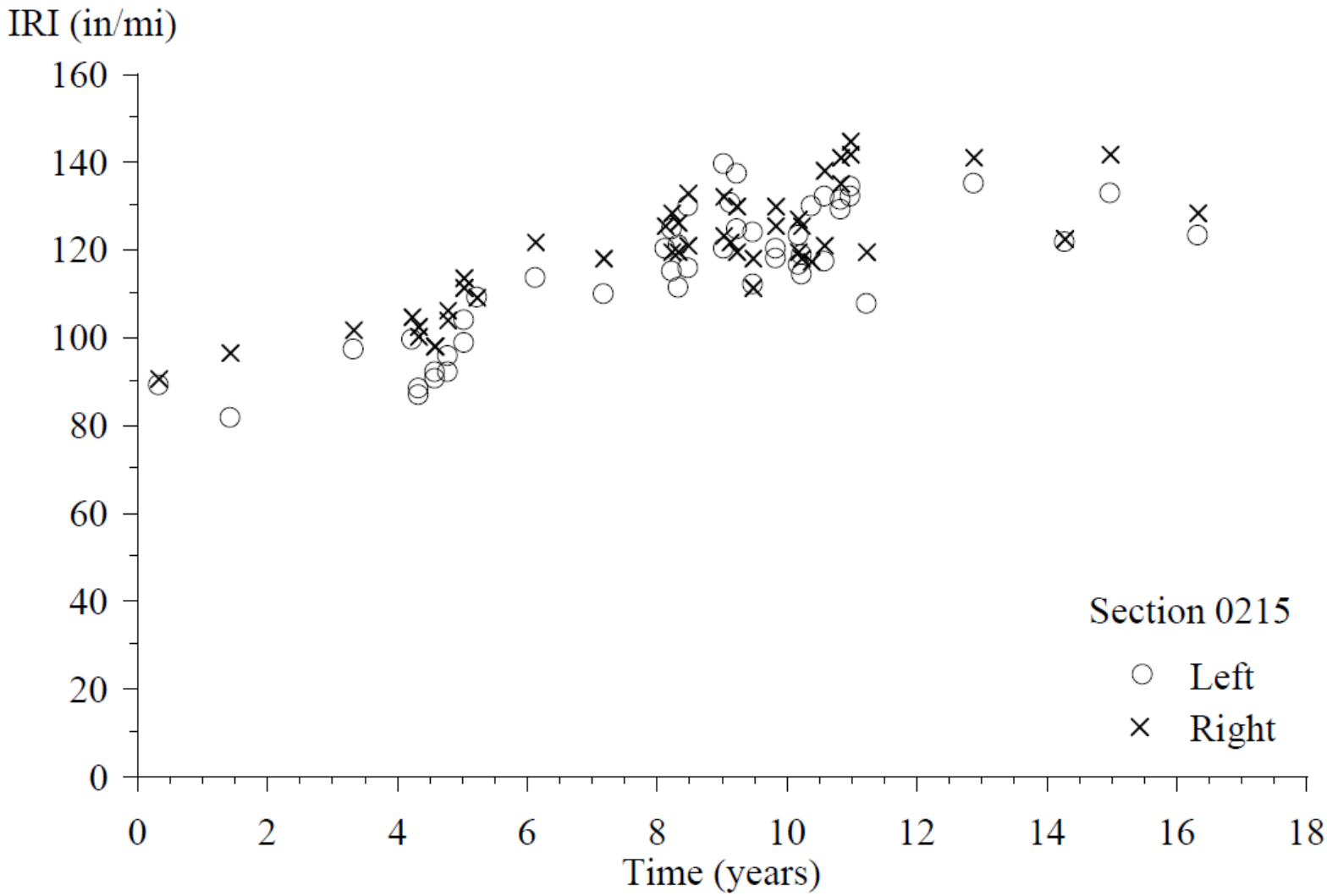


From Peter Taylor

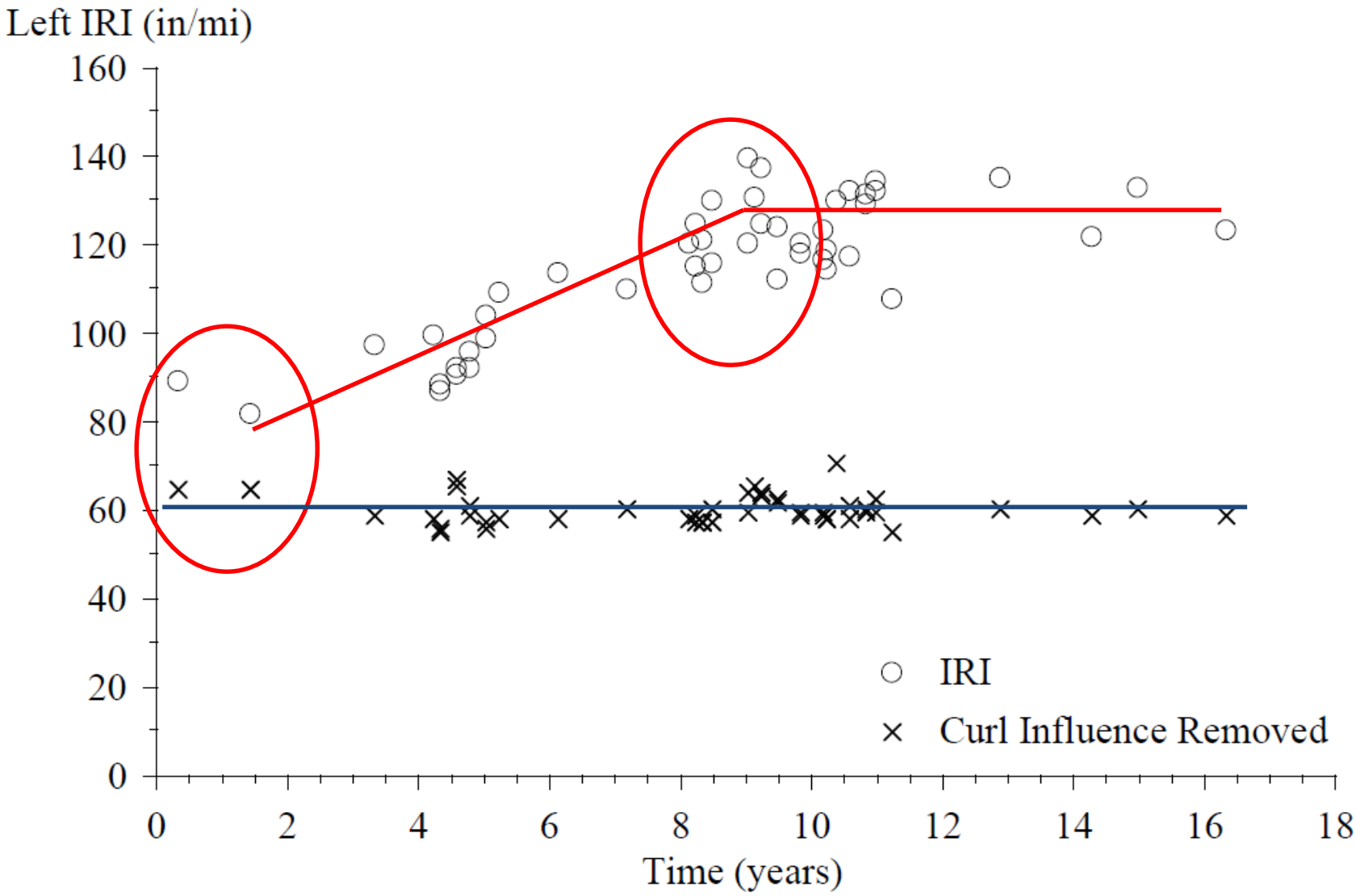
Capillary Pores, Drying Rate, and Magnitude of Shrinkage



IRI Progression for AZ SPS-2 Section 040215



IRI Progression (Section 040215)



How Do We Mitigate Effects of Shrinkage?

- Reduced cement content
  - Less cement paste, less shrinkage, less warping
- Internal curing
  - Appears to reduce shrinkage but long-term effects not established
- Shrinkage reducing admixtures
  - Adds 20% to the cost of concrete
- Shorter joint spacing
- Diamond grind more often

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Durability

- In Northern NV, F-T and deicer use is important
  - Air entrainment, durable paste, and good finishing and curing
  - Brine deicers are a game-changer
- Alkali-silica reactivity remains an issue
  - Specifications are largely perscriptive
  - Must monitor effectiveness of pozzolans to mitigate
  - Work continues on test method development

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Concrete Pavements in an Urban Environment

- Concrete pavements are known for long life, being relatively maintenance free, and adsorbing less solar radiation
- Maintenance of traffic during construction can be an issue, especially in busy urban corridors
- Jointing is critically important
- Utility cuts can also compromise performance

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Maintenance of Traffic

- Early-opening-to-traffic materials
  - Moderate high-early strength (24 hour opening)
  - Rapid set cement (open in an hour)
  - Precast concrete pavement
- Careful construction staging
- Minimal equipment clearances
- Manage opening times using maturity methods

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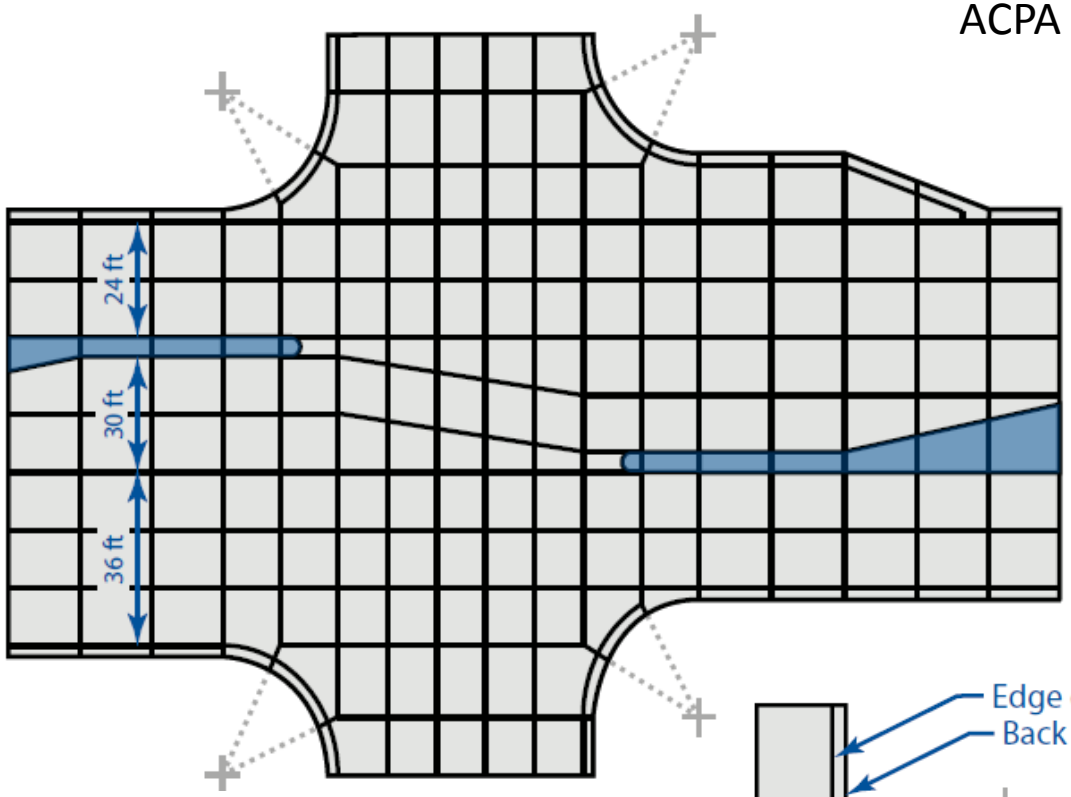
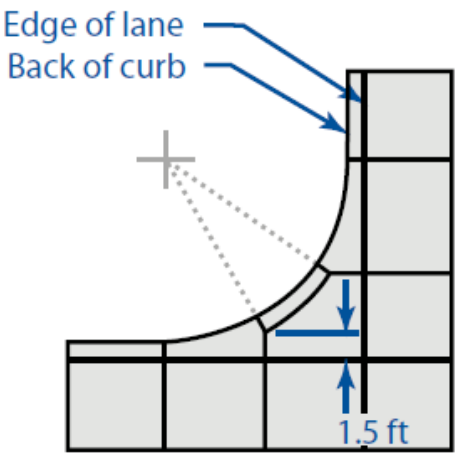
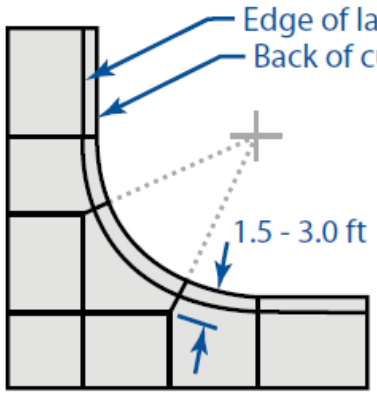
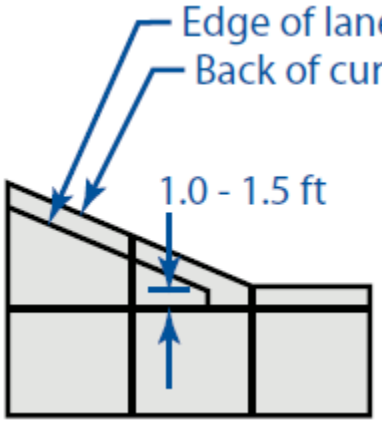
Joint Layout - Intersection

ACPA *Intersection Joint Layout* (IS006.02P)









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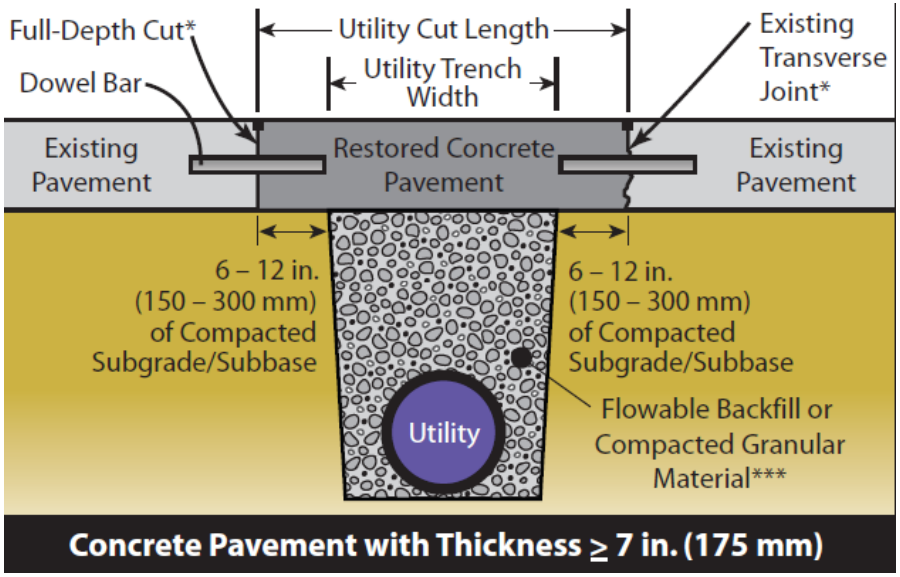
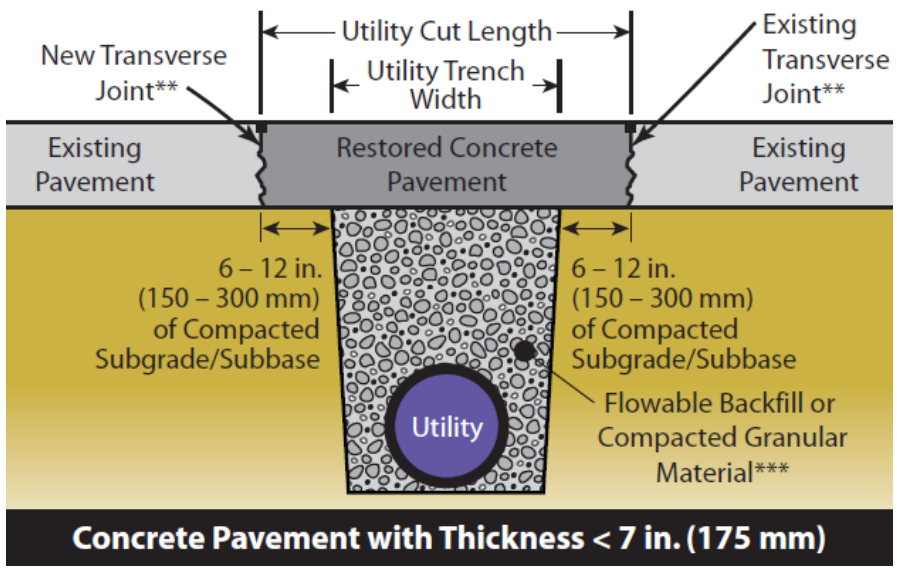
Utility Repairs

- Care should be exercised when repairing utility cuts
  - This is true regardless of pavement type





ACPA *Utility Cuts in Concrete Pavements* (IS235P)

Summary

- In Nevada, we have issues…but nothing that cannot be solved
  - The environment is challenging
  - The materials could be better
- Shrinkage-related problems exist
  - Bridge deck cracking and slab warping
- Durability should not be taken for granted
- Constructing concrete pavements in an urban environment poses new, but manageable, issues

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Questions?