Pavement Underdrain to Achieve Longer Life Pavement Structure

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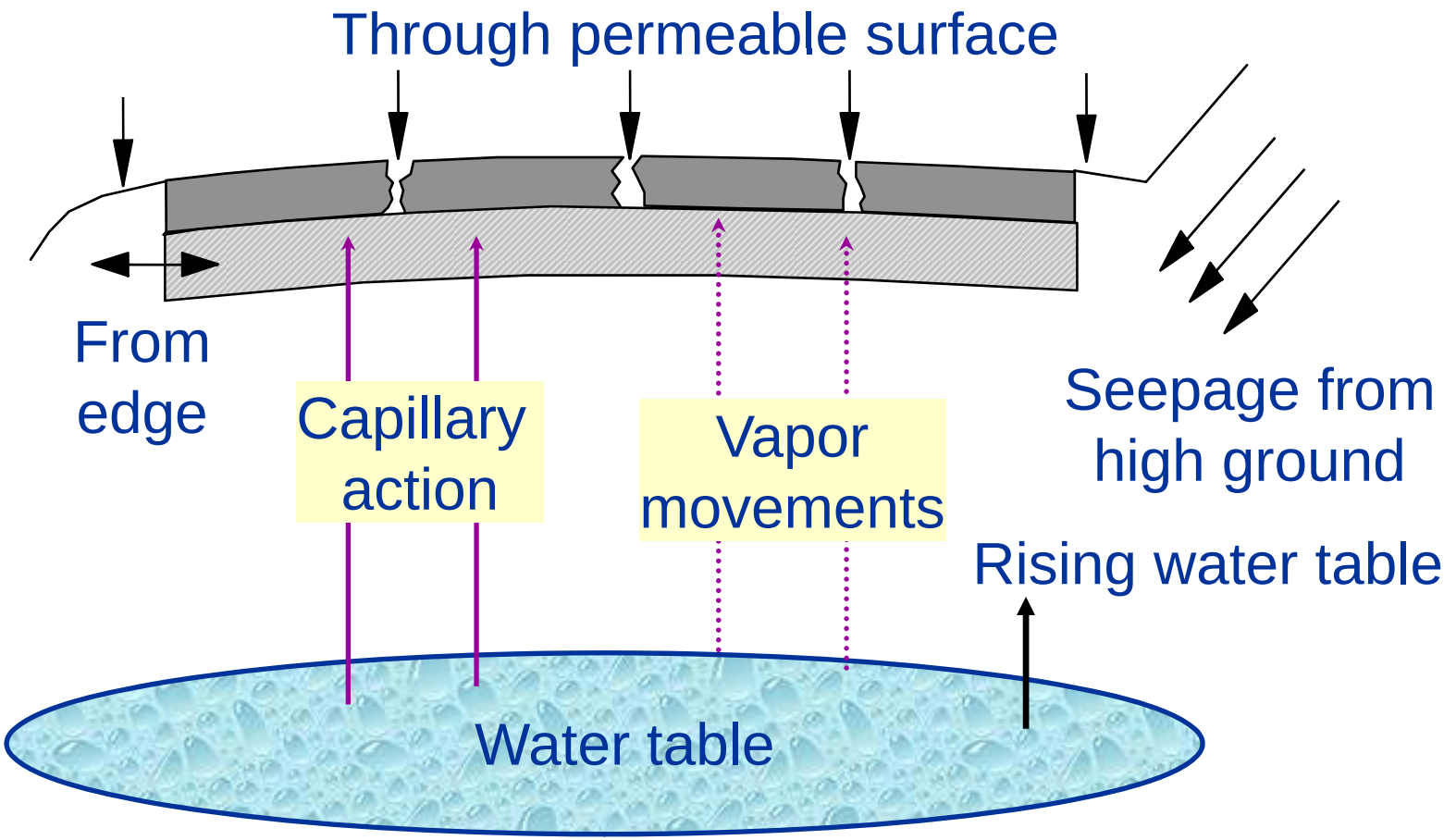
Sources of Moisture



Surface Infiltration

- **Major source of moisture into pavement**
- **Typical values of infiltration ratios for older pavements**
  - HMA pavement: 33 to 50 percent
  - PCC pavement: 50 to 67 percent

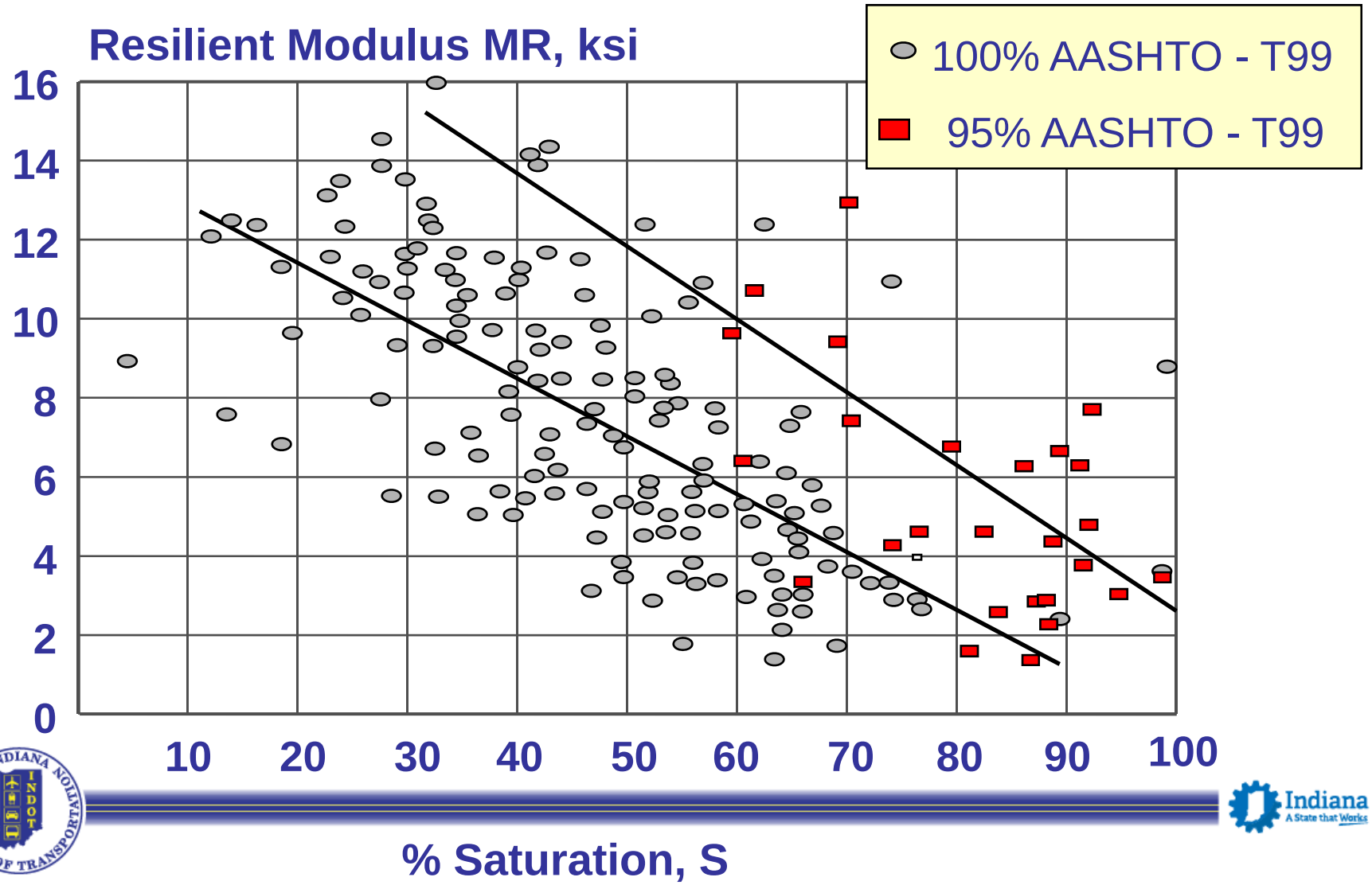
Moisture-Related Damage

- **Moisture-related damage falls into three categories**
  - Weakening of pavement layers
  - Degradation of pavement material (stripping and erosion of HMA, erosion of other materials, D-cracking of PCC)
  - Loss of bond between layers (pavement stripping
- **All three types of damage can occur simultaneously**

Moisture-Related Damage

- More damage when pavement is saturated (e.g., rainy seasons and spring thaw)
- More damage when weakened pavement is subjected to heavy axle loads

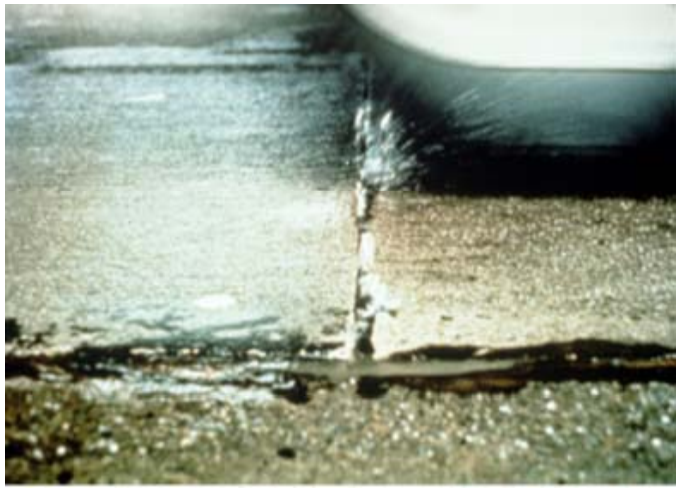
Variation of Resilient Modulus with Moisture Content



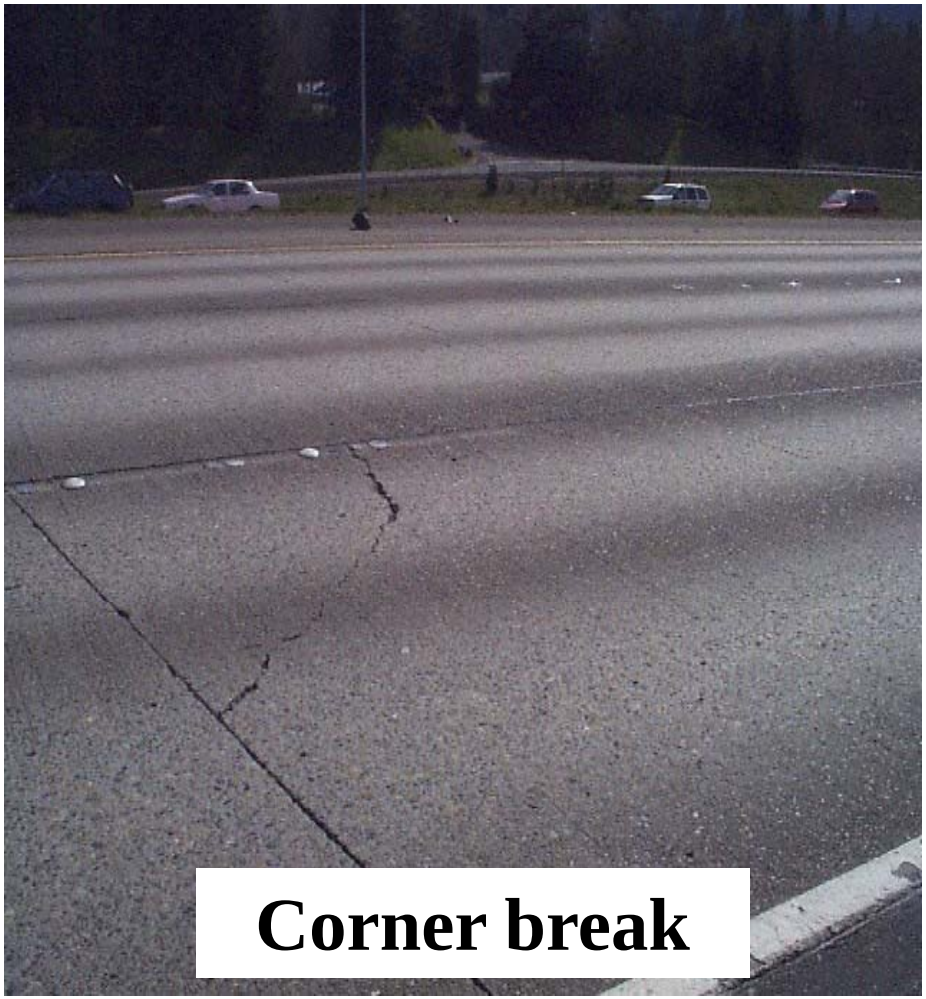
Moisture-Related Distresses PCC

- Pumping
- Faulting
- Corner cracking
- Transverse cracking
- D-cracking
- Alkali-silica reaction

Pumping

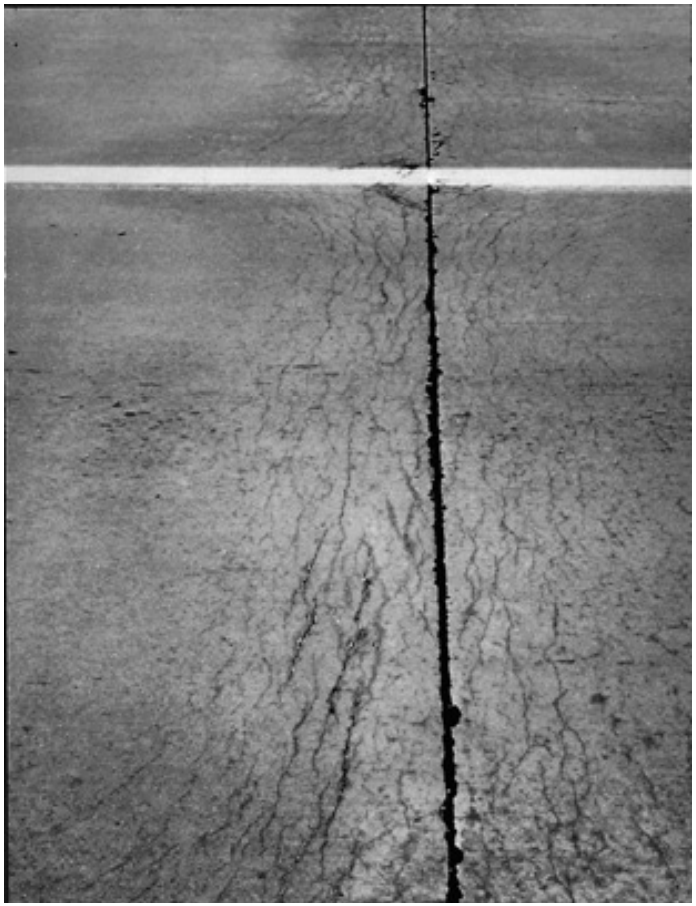


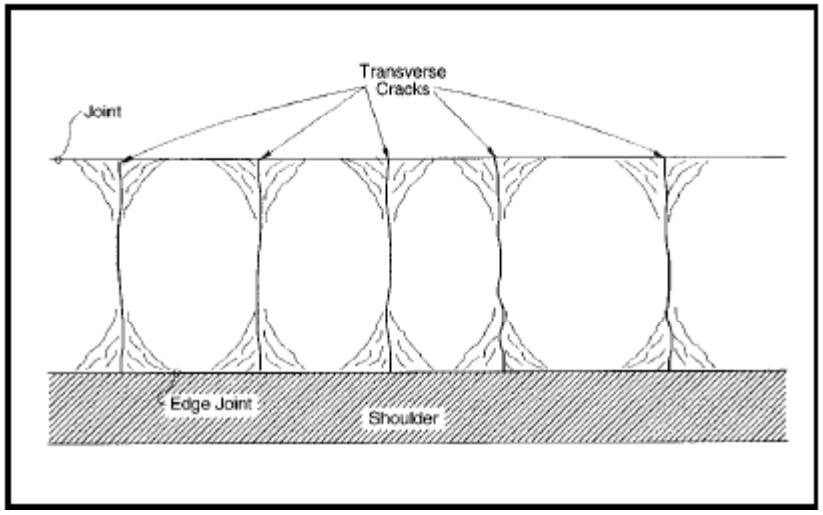
Faulting



Corner break

Punch-out





D-cracking

Moisture-Related Distresses – HMA

- **Rutting of unbound layers and subgrade**
- **Potholes**
- **Alligator / fatigue crack deterioration**
- **Pumping of fines**
- **Stripping of asphalt**

Rutting

Alligator (fatigue) cracking

Pumping

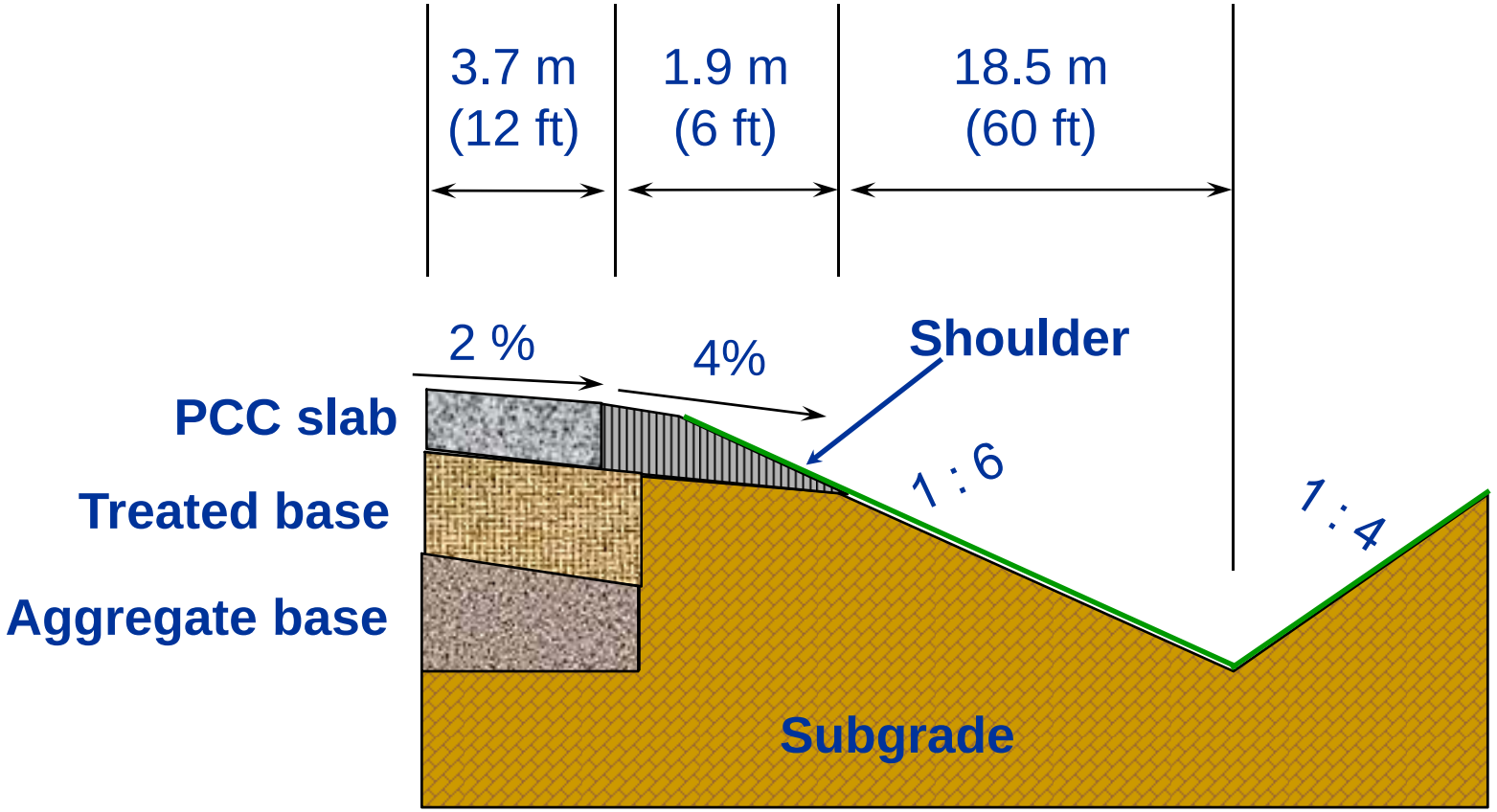
High-severity pothole

AC stripping and erosion

Approaches to Addressing Excess Moisture

- **Prevent moisture from entering the pavement**
  - Pavement geometry (slopes and ditches)
  - Crack sealing/resealing (HMA)
  - Joint and crack sealing/resealing (PCC)

Crowned Cross Slopes



Approaches to Addressing Excess Moisture

- **Use non-erodible base materials**
  - Granular pavement base (open graded)
  - Cement-treated base (CTB), open graded
  - AC-treated base (ATB) with adequate asphalt binder fortified with anti-stripping agents (INDOT specified PG 76-22)

Approaches to Addressing Excess Moisture

- **Other design features that reduce PCC pavement moisture damage**
  - Dowels
  - Tied shoulders
  - Widened lanes
  - Thick granular base (with granular subbase for underdrain)

Approaches to Addressing Excess Moisture

- **Quickly remove infiltrated moisture by incorporating drainage systems in pavements**
- **INDOT Permeable base permeability**
  - Granular open graded +/- 8,000 ft/day
  - Stabilized open graded +/- 3,000 ft/day
- **FHWA recommendations**
  - Time-to-drain of less than 2 hours
    - Permeability values in excess of 300 m/day (1000 ft/day).

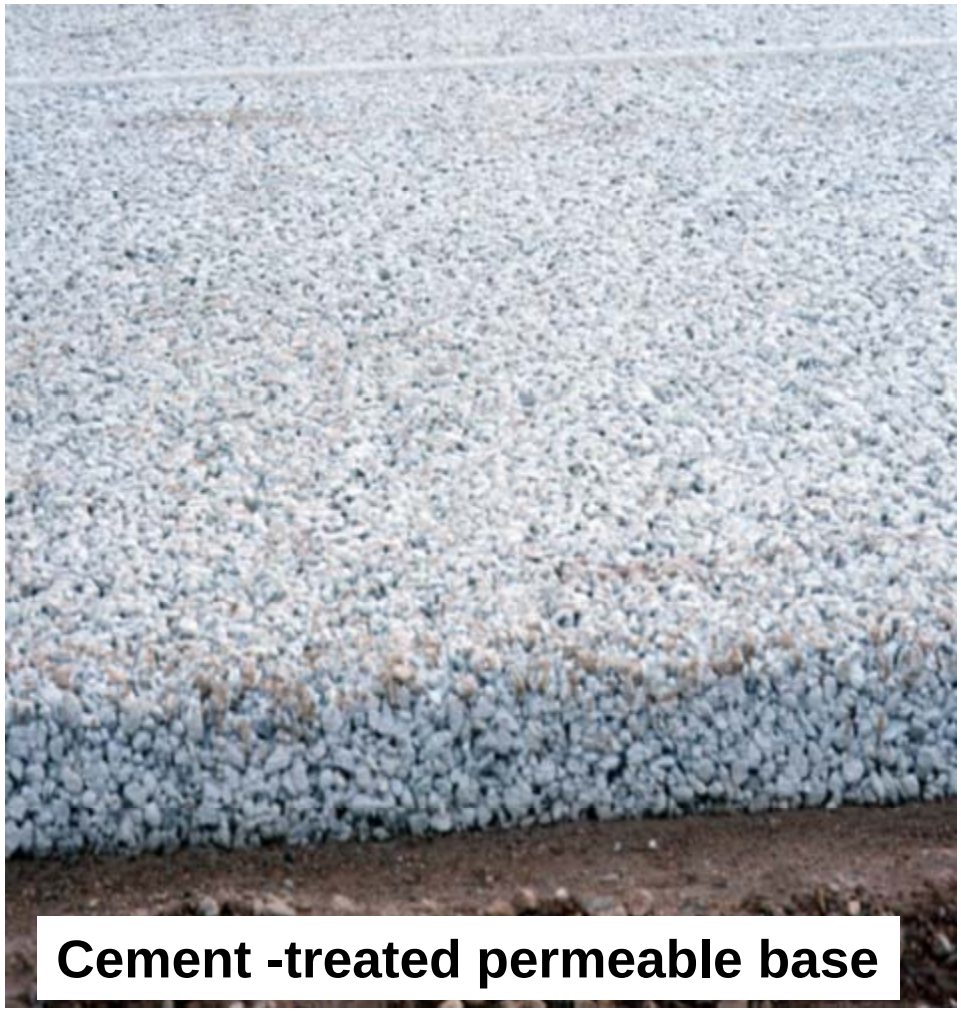
Approaches to Addressing Excess Moisture

- **Combination of approaches can be used for pavements under heavy traffic**
  - Minimize infiltration of moisture
    - Pavement preservations
  - Use non-erodible base materials
    - Granular base (stabilized and non-stabilized)
  - Use design features that reduce moisture damage
    - Provide dowel, ditches, etc.
  - Provide subsurface drainage

Permeable Base

Thick granular / stabilized open graded permeable base

Permeable Base



Cement -treated permeable base

- Open-graded drainage layer
- Can be treated or untreated
- Could be daylighted or edgedrained

JPCP cross section

- 9” – 15” JPCP
- 3” Open graded stone
- 6” - 12” Dense graded stone
- 14” Soil treatment
- Soil subgrade

HMA pavement cross section

- 1.5” Surface
- 2.5” Intermediate
- 3”+ Dense graded base
- 3” Open graded base
- 3” Dense graded base
- 14” Soil treatment
- Soil subgrade

Separator Layer

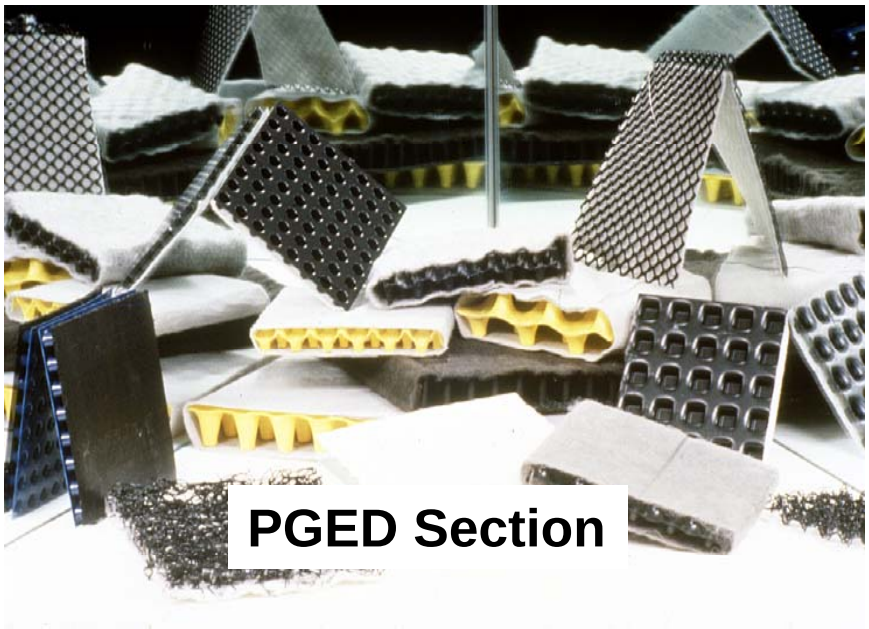
- A dense-graded aggregate layer or a geotextile layer with low permeability (suitable permitivity)
- Used along with a permeable base
- Maintains separation between the subgrade and the permeable base
- Deflects surface infiltration towards the edgedrains

Pipe Edgedrains

Longitudinal pipe edgedrain

- Perforated metallic or plastic pipes
- Run along the pavement length
- Intercept water exiting the pavement

Prefabricated Geocomposite Edge drains



PGED Section

- **PGED**
  - Also called “panel” or “fin” drains
  - Rigid plastic core wrapped with a geotextile
  - Lower hydraulic capacity than a pipe
  - Used in limited retrofit applications

Outlet Pipes

- **Short metallic or plastic pipes connected to the edgedrains**
  - New project 6” pipe, retrofit is 4” pipe
- **Perpendicular to the roadway**
- **Spaced at regular intervals**
  - INDOT is <400 feet, typically 300 feet
- **Carry water from edgedrains to the side ditches/storm drains**

Side Ditches/Storm Drains

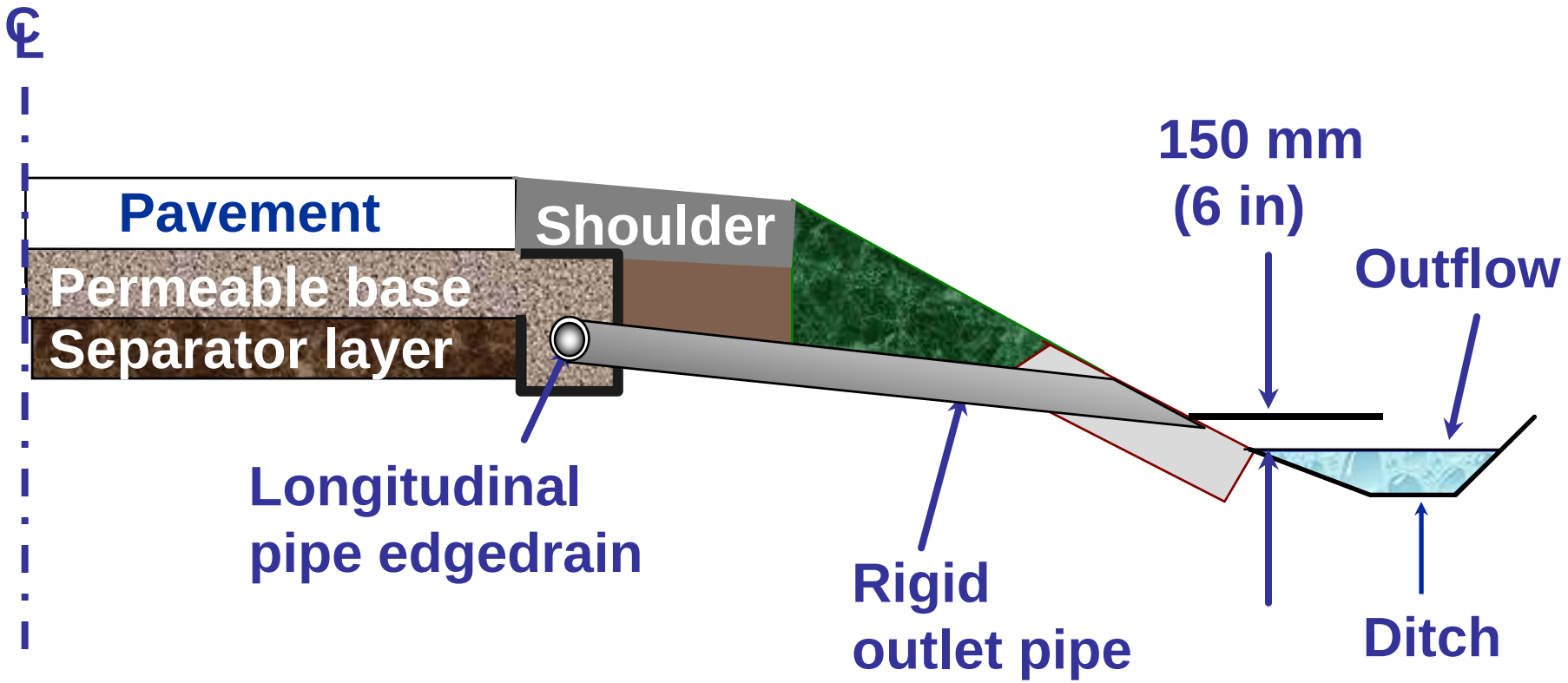
- Carry water from the outlet pipes and surface runoff away from the pavement
- Should have adequate depth
- In urban locations storm drains are used instead of side ditches to collect water

Types of Subsurface Drainage Systems

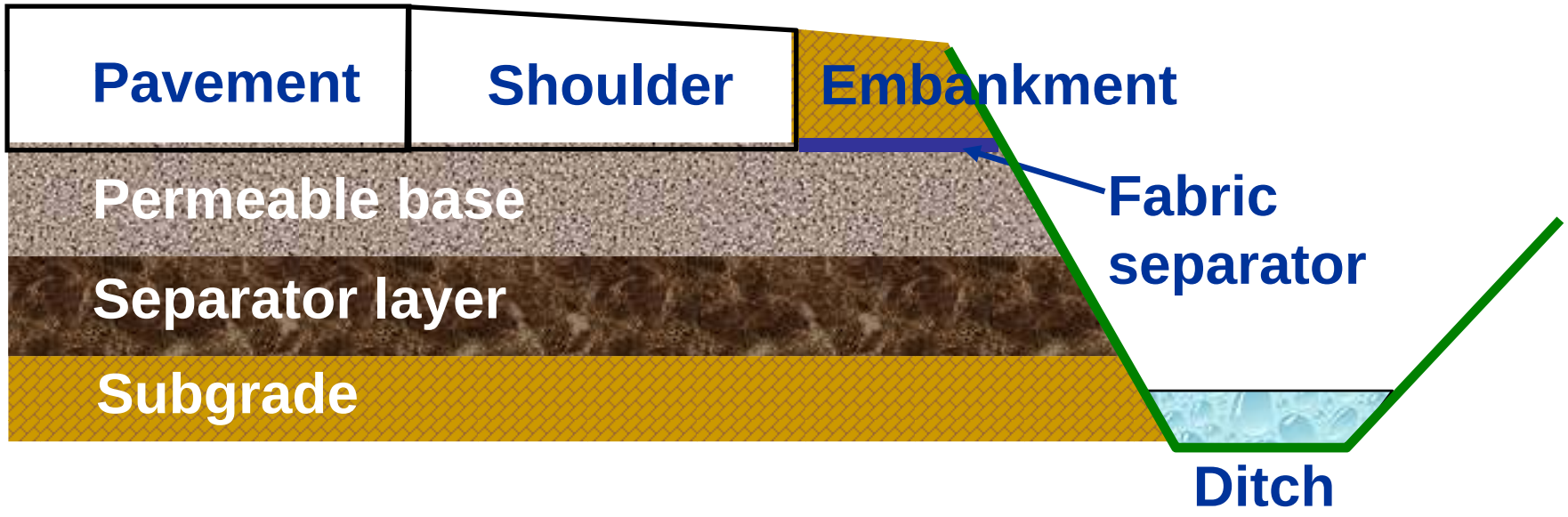
Typical Drainage Systems

- **Permeable base system**
  - Permeable base
  - Separator layer
  - Longitudinal edgedrains or daylighting
  - Outlet pipes and ditch or storm drain

Permeable Base System with Edgedrains



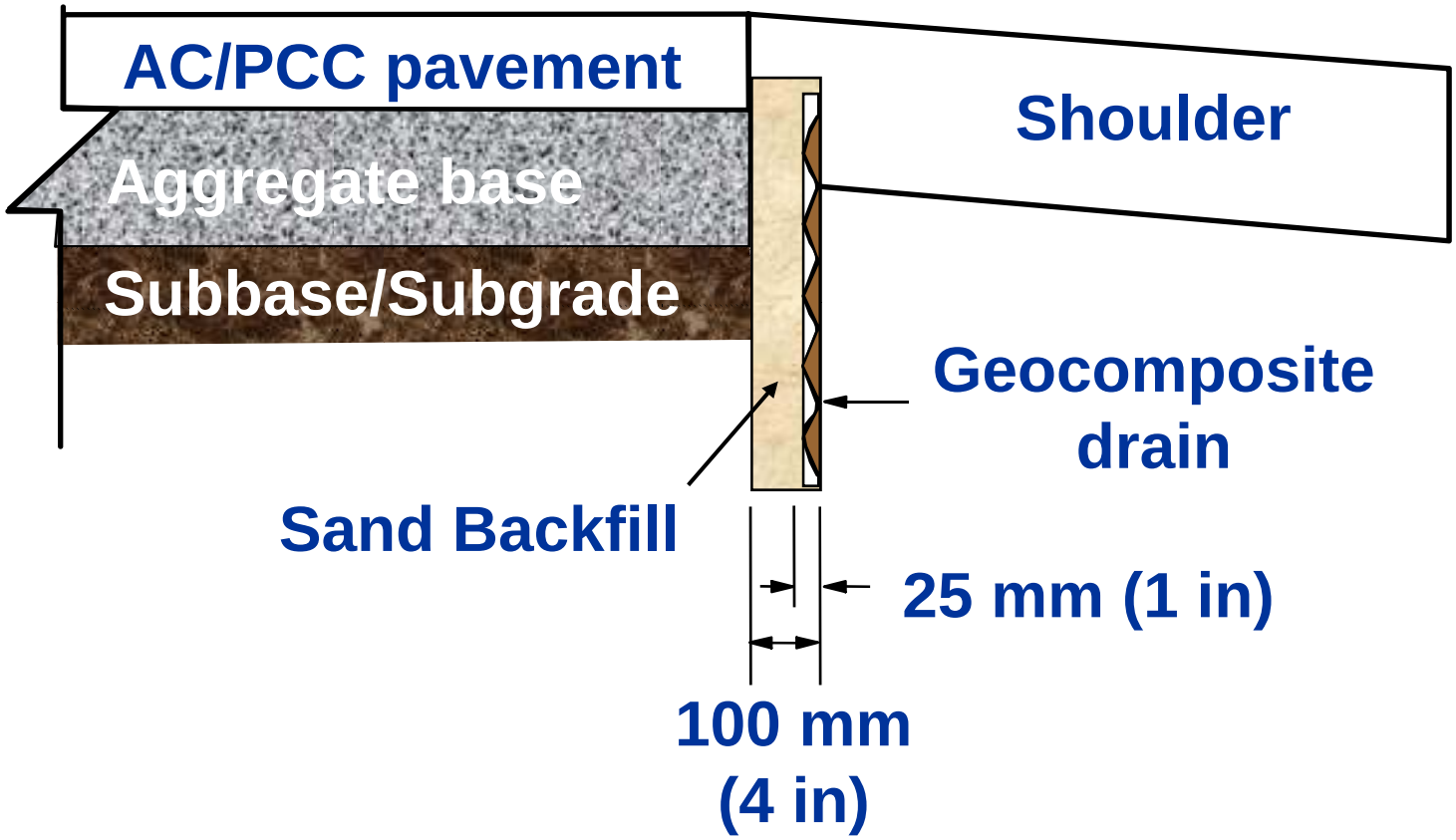
Daylighted Permeable Base



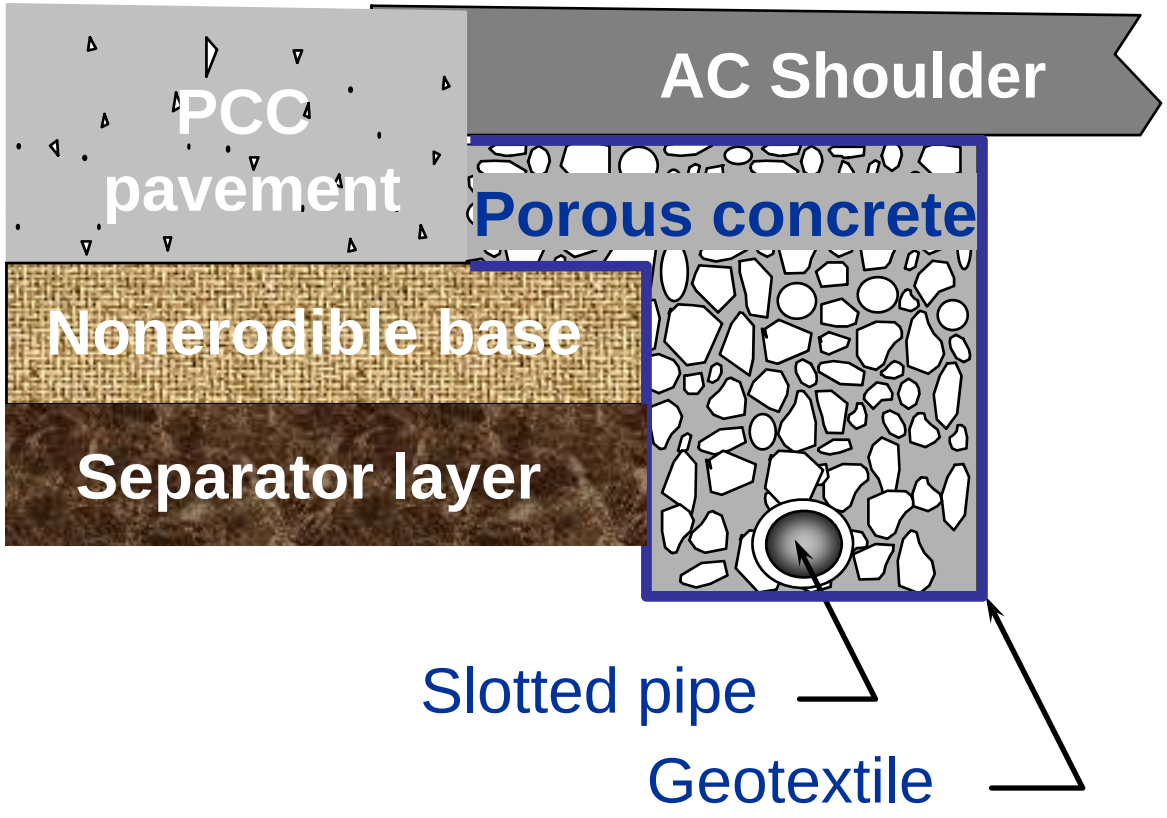
Other Types of Subsurface Drainage Systems

- **Longitudinal edgedrain systems with**
  - Erodible or non-erodible base
  - Pipe drains or geocomposite drains
  - Outlet pipes and ditch/storm drain
- **Non-erodible base with porous concrete shoulder (for PCC pavements)**
- **Daylighted dense-graded bases (DGAB)**

Example Section with Geocomposite Edgedrains

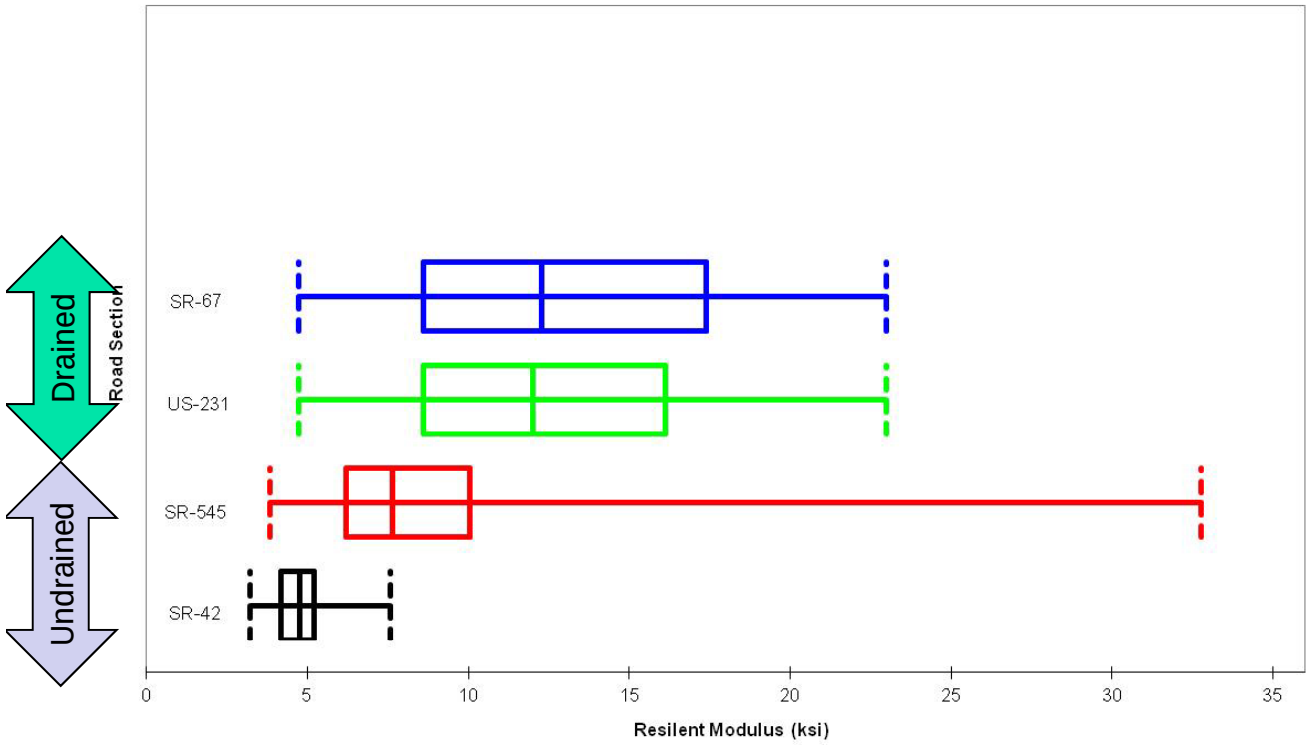


Non-erodible Base with Porous Concrete Shoulder



Structural Benefits of the Drainage Systems

Subgrade Resilience Modulus



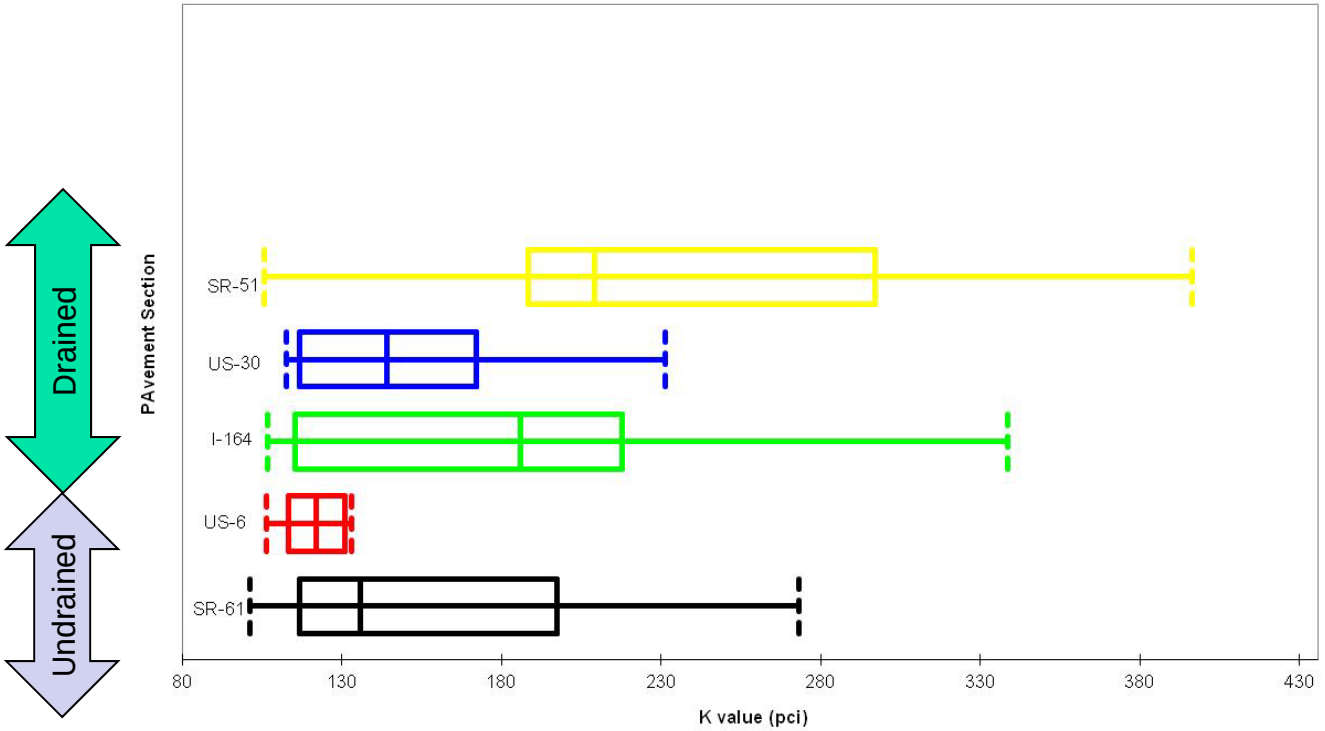
SR-67: A-4 or A-7-6
(Lime Modified Subgrade)

US-231: A-4
(Lime Modified Subgrade)

SR-545: A-4 or A-6

SR-42: A-4 or A-6

Modulus of Subgrade Reaction (k)



SR-61: A-4 or A-6

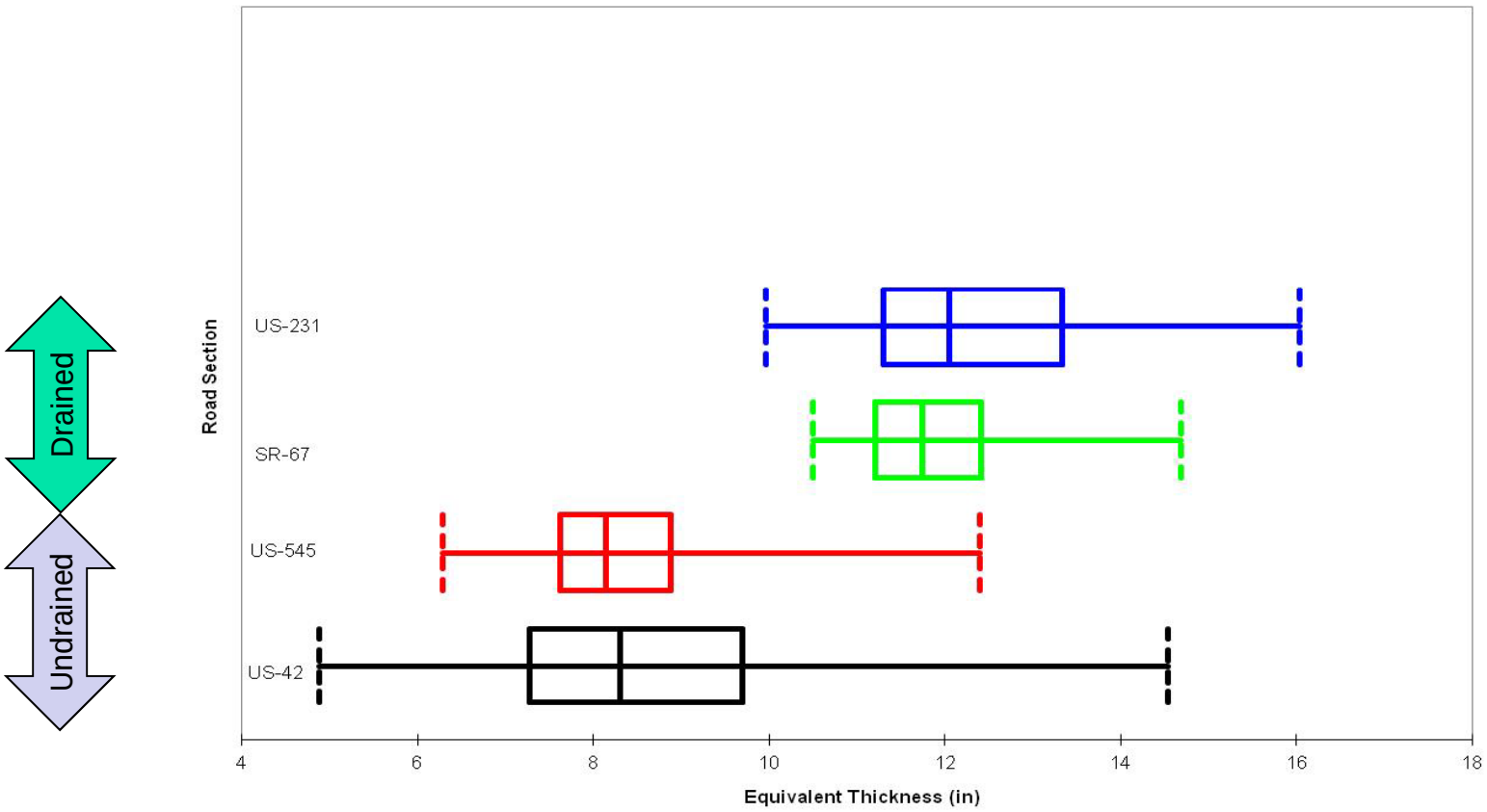
US-6: A-3 or A-2-4

I-164 : A-4 or A-6

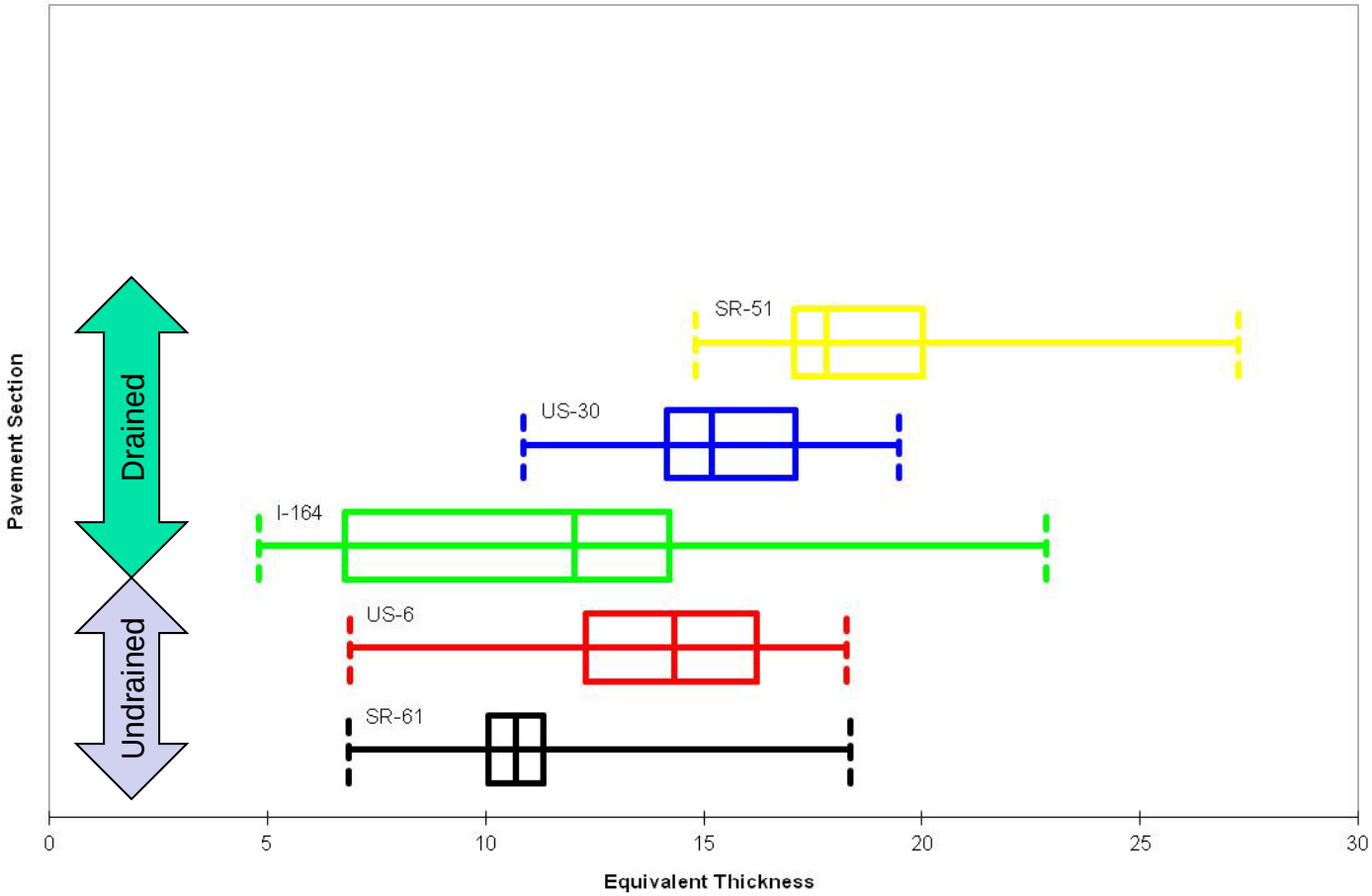
US-30: A-6

SR-51: A-3

HMA Equivalent Thickness



PCC Equivalent Thickness



Common Mistakes in Pavement Underdrain

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Common Mistakes in Pavement Underdrain

Summary

- Surface infiltration represents a major source of moisture in the pavement
- Moisture can be detrimental to pavement performance
- Drainage systems should be designed to remove moisture from pavement before damage occurs

Summary

- **Pavement drainage system provides significant structural benefits to the pavement structure**
- **Subsurface drainage is a viable option to address moisture problems**
- **Various subsurface drainage alternatives exist**

QUESTIONS???