Pavement Underdrain to Achieve Longer Life Pavement Structure

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Sources of Moisture

- Through permeable surface
- From edge
- Capillary action
- Vapor movements
- Seepage from high ground
- Rising water table
- Water table
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

Resilient Modulus MR, ksi

% Saturation, S

100% AASHTO - T99
95% AASHTO - T99
Moisture-Related Distresses PCC

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

Punch-out

photo courtesy of FHWA
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
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)
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 preservation
  - 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

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

Cement treated permeable base
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 permeability)
- Used along with a permeable base
- Maintains separation between the subgrade and the permeable base
- Deflects surface infiltration towards the edgedrains
Pipe Edgedrains

- Perforated metallic or plastic pipes
- Run along the pavement length
- Intercept water exiting the pavement
Prefabricated Geocomposite Edge drains

- **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

- Pavement
- Permeable base
- Separator layer
- Shoulder
- Longitudinal pipe edgedrain
- Rigid outlet pipe
- Outflow
- Ditch

150 mm (6 in)
Daylighted Permeable Base

- Pavement
- Shoulder
- Embankment
- Permeable base
- Separator layer
- Subgrade
- Fabric separator
- Ditch
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

AC/PCC pavement
Aggregate base
Subbase/Subgrade

Shoulder
Geocomposite drain
Sand Backfill

25 mm (1 in)
100 mm (4 in)
Non-erodible Base with Porous Concrete Shoulder

- PCC pavement
- Nonerodible base
- Separator layer
- Porous concrete
- Slotted pipe
- Geotextile

AC 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

![Diagram showing distribution of K values for various pavement sections.](image-url)
HMA Equivalent Thickness

Equivalent Thickness (in)
Common Mistakes in Pavement Underdrain
Common Mistakes in Pavement Underdrain
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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???