Introduction & Review of New IDM
Chapter 304
Comprehensive Pavement Analyses

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2015 Purdue Road School
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In 1818 the Institution of Civil Engineers was founded in London, and in 1820 the eminent engineer Thomas Telford became its first president. The institution received a Royal Charter in 1828, formally recognizing civil engineering as a profession. Its charter defined civil engineering as:

The art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states, both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks for internal intercourse and exchange, and in the construction of ports, harbors, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and application of machinery, and in the drainage of cities and towns.
The art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic …
INDOT will plan, build, maintain and operate a superior transportation system enhancing safety, mobility, and economic growth.
INDOT FY 2015-16 GOALS

- 21st Century, One INDOT Results

- On-time and On-budget
  - Deliver projects in accordance with key performance indicators and INDOT performance measures.
  - Deliver quality services according to identified work plans and within financial targets.

- Take Care of What We Have
  - Implement a plan that maintains steady improvement in pavement and bridge quality.
  - Ensure a commitment to safety.
  - Implement a talent management system that links strategy and operations to results.
  - Establish a culture of continuous improvement.

Customer Satisfaction

- Improve internal and external customer satisfaction.
- Take an outside in view to ensure the highest level of customer service.
INDOT Profile

- Six district offices
- 3,400 employees
- $1 billion/annual capital expenditures
- 28,400 total roadway lane miles
- 5,300 INDOT-owned bridges
- Assists 42 railroads in planning & development of more than 3,880 miles of active rail lines
- Supports 69 Indiana State Aviation System Plan airports
1. **Respect** — Treat others fairly. Value the individual skills, experience, diversity and contributions of fellow employees.

2. **Teamwork** — Share information and seek input from co-workers and agency partners to achieve goals.

3. **Accountability** — Take personal responsibility for actions and decisions.

4. **Excellence** — Provide exceptional customer service through individual initiative, innovation and delivery of quality results.

Values are the core behaviors that all employees, as an organization, will support, promote and exhibit to achieve agency goals.
Pavement Surface Conditions Over 10-Years for Current Funding Trends

Miles of Roadway

- 2014: 9,486
- 2015: 9,472
- 2016: 9,513
- 2017: 9,526
- 2018: 9,474
- 2019: 9,395
- 2020: 9,356
- 2021: 9,318
- 2022: 9,279
- 2023: 9,240
- 2024: 9,202

Assumes Flat $322M Annual Investments 2018-2024

- $299M
- $275M
- $417M
- $380M

IN policy for CAFR reporting, minimum requirement (12.2%)

Pavement condition should remain relatively static at the current investment levels.

Joint Transportation Committee
**Current Service Level**

11.4% Poor in 2024

$394M Annual Investment
10-Years
1,305 Miles of Poor Pavement

**INDOT’s Target Service Level**

≤7.5% Poor in 2024

$498M Annual Investment
10-Years
826 Miles of Poor Pavement

**INDOT’s Recommended Service Level**

≤4.75% Poor in 2034

$561M Annual Investment
20-Years
533 Miles of Poor Pavement

What is the acceptable result for the taxpayer?
Time to failure - Distress levels

Predicted Total Rutting (Permanent Deformation)

- Threshold Value
- @ Specified Reliability
- @ 50% Reliability

Rutting Depth (in)

Pavement Age (years)

0.75
0.64
0.54
0.2
0.1
0
2 4 6 8 10 12 14 16 18 20

3/19/2015
Informed Owner’s Considerations

What We Want:

- Best Service Life/Cost ratio
- Acceptable Service Level
- Least Cost to Own/Operate
Elements of Reasoning

Taking thinking apart...

We reason for a point of view; and from a point of view.

We use information; we draw inferences and conclusions; to answer a question or solve a problem;

We examine concepts and theories; which is based on assumptions;

having implications and consequences;
Universal Intellectual Standards

Testing the quality of your thinking.

- Clarity
- Accuracy
- Precision
- Relevance
- Depth
- Breadth
- Logic
- Significance
- Fairness

A good start...

What standards might you add for your discipline?
Owner Expectations:

- Engineers develop a better plan defined by a structured mental model construct:
  - Cognitive domain
  - Affective domain
  - Critical Reasoning
    - Intellectual Standards
    - Elements of Reasoning
  - Semi-formal Decision-making Process
Different options (5-6) were analyzed
Designed with least cost/lane mile/year
Saving tax payers money with smooth pavement as end product
Pavement Evaluation

- Field evaluation-Existing pavement pictures
- Core Report
- FWD Report
- Pavement Management data
- Old contracts review
Geotechnical Involvement general information point

Historically, geotechnical “error” is reportedly one of the reasons/drivers of large and expensive AoCs (advice of changes)

i.e., CHANGE ORDERS that bust project budgets

How do we change that?
Structural Design

- Pavement structural design was achieved by
  - Standards or catalogs
  - From the 1800s well into the 1900s
Definitions – Flexible Pavement

Key:
1: A.C. surface course
2: base
3: sub base
4: compacted road
5: subgrade
6: concrete surface
7: roadbed
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
Foundation Soil
JPCP Bottom-Up Cracking –
(Mid-slab Load + Positive Curl/Warp Condition)

Critical stress region at bottom of slab

Base
Subgrade
JPCP Top Down Cracking
(Joint Load + Negative Curl/Warp Condition)

Critical stress region at top of slab

Base
Subgrade
Stress and strain in rigid pavement – Curling stress

Daytime Downward Curling
(+) Positive Gradient

Nighttime Upward Curling
(-) Negative Gradient

JPCP
Drainable Base
Soil Subgrade

Tension

Compression
J PCP cross section

11” – 13” J PCP
3” Open graded stone
6” - 12” Dense graded stone
14” Soil treatment

Soil subgrade
Foundation Soil
Overview of MEPDG Software

http://www.trb.org/mepdg/software.htm
(Search for MEPDG software)
JPCP design feature, layers, and material properties

- Traffic
  - Traffic Volume Adjustment Factors
    - Monthly Adjustment
    - Vehicle Class Distribution
    - Hourly Truck Distribution
    - Traffic Growth Factor
  - Axle Load Distribution Factors
- General Traffic Inputs
  - Number Axles/Truck
  - Axle Configuration
  - Wheelbase
- Climate
- Structure
  - Design Features
  - Layers
    - Layer 1 - JPCP
    - Layer 2 - Crushed stone
    - Layer 3 - Crushed stone
    - Layer 4 - A-7-6
    - Layer 5 - A-7-6
HMA design properties, layers, and thermal cracking
**Design process**

**Design Input (Level 1, 2, or 3)**

**Environment**
- Temperature
- Precipitation

**Materials**
- PCC
- Base
- Subgrade

**Traffic**
- Axle classification
- Axle loads

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- Process raw input for PCC distress modeling
- Assemble input and trial design information for each distress model
- **Perform design analysis** (predict distress)
- Compute IRI over Design Period (Initial IRI, Distress, Climate, Subgrade)

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- **Trial Design**
- Requirements satisfied?
  - **No**
  - Revise trial design
  - **Yes**
  - Design completed
Pavement Analysis-Design

- **Historical**
  - Chart-based AASHTO ‘93 method
  - No meaningful performance expectation
  - Resurface = 3-16 yrs?

- **MEPDG**
  - Mechanistically sound, empirically calibrated
  - Determines performance expectations
    - i.e., years of acceptable condition
Some data examples -

- Traffic: AADT, truck vol
- Condition: IRI, rut, cracking type & severity, friction, structural adequacy, drainage,
- Inventory: location, geometrics
- Materials: soils, HMA mix, PCC mix
- History: maintenance, construction, jurisdictional
Current Pavement Asset Management Strategic Direction

- Initial engineering perspective
  - No problems
  - Minor flaws
  - Major flaws
  - REAL MAJOR PROBLEMS

- Refer to more detailed, precise pavement assessment
  - Type, severity, extent of pavement distresses
Current Pavement Asset Management Strategic Direction

- Engineering problem - AM perspective
  - No problems
  - Lack of maintenance
  - Rough ride
  - Beginning of structural deterioration
  - Advanced structural deterioration
  - Structurally failed
  - Roadside / drainage problems
Current Pavement Asset Management Strategic Direction

- Business owner perspective
  - Is the pavement unacceptable or not?
  - Different managerial approaches depending on the previous question’s answer
Management Strategic Direction

- Pavement is unacceptable now
  - Do something now!
  - WORST FIRST maybe

- Priority of effort
- Not necessarily a strategic fix
- GET IT OUT OF UNACCEPTABLE category
- Maybe least bad solution?
Current Pavement Asset Management Strategic Direction

- Pavement is acceptable
  - Least cost of ownership approach
    - $/lane-mile year of service purchased
  - Optimized cost-effective right-treatment at right time for right cost approach
- Or bridging strategy or approach
Current Pavement Asset Management Strategic Direction

- Possible fixes
  - Do nothing
  - Routine maintenance
  - Reactive maintenance
  - Preventative maintenance or PPI (pavement preservation initiative) treatment
  - Structural treatments
Possible fixes (cont.)

- Structural treatments
  - Minor structural rehab/treatment
  - Major structural rehab/treatment
  - Major reconstruction

- Each treatment has several options
- Options have cost, time & benefit ranges
Current Pavement Asset Management Strategic Direction

- Comprehensive list of **NEEDS**!

- Process this list through business guidance
  - Priority of resourcing / effort
  - Effectiveness of relative improvements
  - Priority of relative improvements
  - Funding
- Problem assessment and statement
- Possible solutions
  - Treatment options
- COA screening and evaluation
  - Worst first worst, but necessary
  - Engineering economics intervention point optimization
  - Temporary bridging strategy or approach
Mechanistic-Empirical Pavement Design Guide (M-EPDG) philosophy
Problem assessment and statement - 1

- Pavement Condition
  - Pavement distresses
    - Type
    - Severity
    - Extent
  - Structural Condition
    - Assessment
- Functional Condition
  - Assessment
- “Functional Overlay” term?
Outline

- INDOT Business Case (David Holtz)
- General Chapter 304 outline (Kumar Dave)
- MEPDG Specifics (Kumar Dave/Lisa Egler-Kellems)
- Geotechnical Aspects (Kumar Dave/Nayyar Siddiki)
- Other Issues, Construction & Maintenance, Alternate Bidding..
- Current Status
Chapter 304

Comprehensive Pavement Analysis

- Published in 2014
- Rewrite of Manual after 2009
- Brand New Chapter (>50 meetings)
- Many new Topics added
- Ch 52 superseded by Ch 304
Comprehensive Pavement Analysis

- Introduction
- History
- INDOT Pavement Analysis Philosophy
- Pavement Project Categories
- Pavement Type Selection
- Pavement Types
- Pavement Distresses
- Pavement Milling
Comprehensive Pavement Analysis

- Pavement Patching
- Pavement Widening
- Pavement Testing
- MEPDG
- HMA Pavements and Pay Items
- PCCP Pavement and Pay Items
- Miscellaneous Pavement Project Elements
- Underdrains
- Preventive Maintenance
Comprehensive Pavement Analysis

- Life Cycle Cost Analysis
- Typical Pavement Sections
- Pavement Design Request and Instructions
It provide guidance for:

- Investigation
- Evaluation
- Analysis (based on sound engineering principles, economics, geotech, traffic, material & environmental condition)

For public roadway system in Indiana
Comprehensive Pavement Analysis

Indiana Pavements:
- Flexible: HMA
- Rigid: PCCP
- Aggregate
- Brick

Underdrains since 1950s.

Mid 1990 study showed poor performance of underdrain system.

Geocomposite underdrain failed.
NHS were built with different Typical Concrete with 9-7-9 inch thick 18-20 feet wide Tilt sections overlayed & widened with HMA
SH were built with different Typical
9 feet wide
Asphalt with Sand surfaces,
HAE
BCA or Greasy 5’s,
LV, MV, HV mixes
Majority are overlayed & widened with
HMA
Superpave since 1992
New pavement with safety edge 2011
INDOT Pavement Analysis
Philosophy

• Based on least cost of ownership
• Cost/lane mile/year of life
  • Investigation
    • History, coring, FWD, geotech, PMS

Evaluation: Types & cause of distress
Functional verses structural distress

Analysis: MEPDG, LCCA, Alt pavement Treatments, maintenance Consider
Pavement Design Development

• Preliminary Pavement Design (0 to 30%) of overall project development

• Final Pavement Design (30 to 60%)

• Design Validation (90%)
INDOT Pavement Design Process

INDOT Project:
• Pavement designer (CO, district, consultant)
• Call for project..by Roadway Asset Team
• Pavement designs are being checked, reviewed & signed by 3-4 P.E’s

• LPA Projects
• Pavement designer is the consultant
• Checked by the consultant’s peer
• Reviewed by INDOT
Pavement Project Categories

- New Alignment
- Pavement Reconstruction
- Pavement Rehabilitation
  - Structural overlay
  - Rubblization & overlay
  - Crack & seat & overlay
  - Unbonded PCCP overlay
  - Full deptth reclamaiton
• Preventive Maintenance
  • Surface treatment
  • HMA mill & fill
  • In-place recycling
    • HI P
    • CI P
    • FDR
Pavement Type Selection

Based on specific project considerations:

- Project scope
- LCCA
  - $>$10000 yd$^2$
  - $>$10% difference
  - $<$10% difference

LPA can present an argument & justification to use particular type

The pavement type selection panel
Pavement Types

- Aggregate Pavement
- Brick Pavement
- HMA
- PCCP
- Composite
Pavement Distresses

Aggregate pavement
Dusting, potholing, rutting, washboarding

Asphalt pavement
Block cracking, rutting, thermal cracking, fatigue cracking etc

PCCP
Faulting, joint failure, poor rideability etc

Ref: Distress Identification Manual LTTP
Pavement Milling

Asphalt or PCCP Scarification Milling

Asphalt or PCCP Profile Milling

Approach Milling

Asphalt or PCCP Milling

Asphalt Overlay Removal

Transition Milling
Pavement Patching

PCCP Patching, Full Depth

HMA Patching

Composite Patching

  Partial Depth Patching
  Full Depth Patching

Patching Table required

Concrete Patching has more issues.
Pavement Widening

- Widening with HMA
- Widening with PCC Base
- Widening for Composite Pavements
  - 2020 projects
MEPDG

Mechanistic-Empirical Pavement Design Guide
• State-of-art tool for design and analysis of new and rehabilitated pavement structure

• Based on M-E principles

• Calculates pavement responses (stresses, strains & deflection)

• Uses responses to calculate damage over time

• MEPDG predicts multiple performance indicators
MEPDG is an iterative process.

Outputs are pavement distresses and not tk.

Trial design is based on performance criteria.

Level 1, 2, 3

Performance criteria for flexible pavement:
- Roughness (IRI)
- Rutting
- Transverse cracking
- Fatigue cracking
Performance criteria for Rigid Pavement
Roughness (IRI)
Faulting
Cracking
MEPDG design Considerations

• Foundation/Subgarde
• Existing pavement condition
• Paving material
• Construction factors
• Environmental factors
• Traffic loading
• Subdarinage
• Shoulder design
• Rehabilitation treatment & strategies
Lisa Egler-Kellems
Demostrates AASHTOWare PavementME©
Ref: Section 401 & 402 of INDOT Standard Specification

QC/QA-HMA, __ , __ , __ , __ mm
(ESAL) (PG) (Type) (Mix)
EXAMPLE:

QC/QA-HMA, 4, 76, Surface, 9.5 mm

EXAMPLE:

HMA, __ , __ HMA, Type B, Surface
(Type) (Course)
PCCP Pavement

Ref: 501 & 502 of INDOT Standard Specification

CPR

CRCP

QC/QA-PCCP,10 in

PCCP 10 in
Geotechnical Aspects
New Indiana Design Manual

Nayyar Siddiki, P.E.
Geotechnical Construction & Technical Support Engineer,
INDOT

March, 2015
IN Design Manual Sect. 304-14.05

Subgrade Material:

- Prepared Subgrade layer
- Natural Subgrade layer

Function is to provide the foundation to the pavement.
Pavement, Subgrade & Its Foundation Section

Aggregate No. 53

Drainage Layer & Separation Layer

Subgrade Foundation

Subgrade varies 6 to 24 inches

PCCP
Subgrade Types

Type I

24 in. of soil compacted to density and moisture requirements.

CR-County Road  US-US Route
LS-Local Street   I-Interstate
SR-State Road

<table>
<thead>
<tr>
<th>Road Description</th>
<th>Type of Work</th>
<th>Subgrade Length</th>
<th>Maximum Design $M_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR/SR</td>
<td>New Road, Road Reconstruction and &gt; 6 feet Widening</td>
<td>&gt; 800 feet</td>
<td>$M_R = 6,000$ psi</td>
</tr>
</tbody>
</table>
### Type 1B

14 in. chemical soil modification

<table>
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<th>Type of Work</th>
<th>Subgrade Length</th>
<th>Maximum Design $M_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR/SR/US/I</td>
<td>New Road, Road Reconstruction and &gt; 6 feet Widening</td>
<td>&gt; 800 feet</td>
<td>$M_R = 9,500$ psi</td>
</tr>
</tbody>
</table>
Type 1C

12 in. of the subgrade excavated and replaced with coarse aggregate No. 53

<table>
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<th>Road Description</th>
<th>Type of Work</th>
<th>Subgrade Length</th>
<th>Maximum Design $M_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR/SR/US/I</td>
<td>New Road, Road Reconstruction and &gt; 6 feet Widening OR Reconstruction OR Widening &lt; 6 feet</td>
<td>&lt; OR &gt; 800 feet</td>
<td>$M_R = 9,500$ psi</td>
</tr>
</tbody>
</table>
Con’t.

Type II

6 in. of the subgrade excavated and replaced with coarse aggregate No. 53.

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<th>Road Description</th>
<th>Type of Work</th>
<th>Subgrade Length</th>
<th>Maximum Design $M_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR/US</td>
<td>Road Reconstruction or &lt; 6 feet Widening</td>
<td>&gt; Or &lt; 800 feet</td>
<td>$M_R = 6,000$ psi</td>
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</tbody>
</table>
Con’t.

Type IIA

8 in. chemical soil modification

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<th>Road Description</th>
<th>Type of Work</th>
<th>Subgrade Length</th>
<th>Maximum Design $M_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR/CR</td>
<td>New Road, Road Reconstruction and &gt; 6 feet Widening</td>
<td>&gt; 800 feet</td>
<td>$M_R = 6,000$ psi</td>
</tr>
</tbody>
</table>
6 in. of soil compacted to the density and moisture requirements

<table>
<thead>
<tr>
<th>Road Description</th>
<th>Type of Work</th>
<th>Subgrade Length</th>
<th>Maximum Design $M_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR/or other local roads</td>
<td>Road Reconstruction or Widening</td>
<td>&lt; 800 feet</td>
<td>$M_R = 4,500$ psi</td>
</tr>
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</table>
Type IV

12 in. of the subgrade excavated and replaced with Coarse Aggregate No. 53 on geogrid Type IB.

<table>
<thead>
<tr>
<th>Road Description</th>
<th>Type of Work</th>
<th>Subgrade Length</th>
<th>Maximum Design $M_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR/US/SR/LS/I</td>
<td>Reconstruction and &lt; 6 feet Widening</td>
<td>&gt; 800 feet</td>
<td>$M_R = 9,500$ psi</td>
</tr>
</tbody>
</table>
Type V

3 in. of the subgrade excavated and replaced with 3 in. coarse aggregate No. 53.

Subgrade Treatment for Trails on Abandoned-Railroad Corridor

<table>
<thead>
<tr>
<th>Road Description</th>
<th>Type of Work</th>
<th>Subgrade Length</th>
<th>Maximum Design $M_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bike Paths/Trails</td>
<td>Reconstruction or Widening</td>
<td>----------------</td>
<td>$M_R = 4,500$ psi</td>
</tr>
</tbody>
</table>
When soil is A-7 and modified with Lime, it becomes A-6 in proposed subgrade.

Following are the guidelines for input.

- Subgrade material – review the Geotechnical report
- Coefficient of Lateral Earth Pressure (Ko) - typical value 0.5
- Subgrade thickness – review Geotechnical report
- Natural Subgrade – Goes infinite
 Aggregate Subgrade Layer Design

Non stabilized base – when Geotechnical report recommends aggregate only then layer is input as a crushed stone but with the modulus from Geotechnical report.

Chemically stabilized pavement layer purpose is to provide strength and support the sub-segment layer.

- Specific modifier such as cement or lime
- Layer thickness as recommended Geotechnical report.
Stabilized drainage layer for concrete pavement – Strength etc. based on mix design for a cement stabilized drainage layer

Material layer, layer thickness, Unit weight, Modulus, Modulus of rupture … etc.
Underdrains – the purpose of underdrain is to remove water from the subgrade and pavement structure.

- Designer should refer Geotechnical report for subsurface drains.
- Subsurface drain may be required whereas underdrains are not.

Geotextile for underdrain – review the geotechnical report.
Other Issues, Construction & Maintenance, Alternate Bidding PCCP Pavement

- Pavement History
  - Underdrain installation, cleaning
  - Construction...
  - PCCP Joint failures
  - HMA early failure
  - PCCP Patching with opening to traffic
  - Proper maintenance
  - Alt Bidding is working...saving millions $
Subgrade
Temporary Pavement
Driveways
U-Turn Median Opening
Public Road Approach
Bridge Deck Overlay (Simplified design)
Seal Coat
Prime Coat
Tack Coat
Base Seal
Curbs and shoulders
RCBA
Purpose: Remove water from the subgrade and pavement structure

Warrants: Any of the following condition
- AADTT > 100
- Adjacent pavement has underdrain
- Specific geotechnical condition

Existing Underdrain perpetuation

Underdrains are also required when using subbase for PCCP, HMA OG layer, C&S and rubblization

Underdrains are not typically constructed for PM projects or mill & fill projects.
Preventive Maintenance

Part of overall pavement preservation program

Intended to arrest light deterioration

Does not add structural strength

Proper time is before the pavement experiences severe distresses

PM Service life varies with the treatments
HMA Pavement PM Treatments:

- Crack Sealing and filling
- Fog Sealing
- Seal Coat
- Microsurfacing
- Ultrathin Bonded Wearing Course (UBWC)
- HMA Inlay or overlay
- HIR
- CIR

PCCP PM Treatments

- Crack Sealing
- PCCP Sawing & Sealing Joints
- Retrofit Load Transfer
PCCP PM Treatments:

Surface profiling
Partial Depth Patching
Full Depth Patching
Underseal
Slab Jacking
Stitching
Economic evaluation technique

Consider initial and future agency and other relevant costs

General Requirements: Required for new Alignment, reconstruction, or Rehabilitation with Mainline pavement area > 10,000 syd

Least cost of ownership (cost/lane mile/year) is required to compare various treatment options
JPCP Typical

9” – 13” J PCP
3” Open graded stone
6” Dense graded stone
Subgrade treatment
Soil Subgrade/natural
HMA Typical

1.5” Surface
2.5” Intermediate
3”+ Dense graded base
3” Open graded base
3” Dense graded base
Subgrade treatment
Soil subgrade/natural
Questions?