Introduction & Review of New IDM Chapter 304 Comprehensive Pavement Analyses

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IDM Chap 304 Philosophy

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.

Institution of Civil Engineers, 1 Great George Str, Westminster, London

IDM Chap 304 Philosophy

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 Mission

INDOT will plan, build, maintain and operate a superior transportation system enhancing safety, mobility, and economic growth.

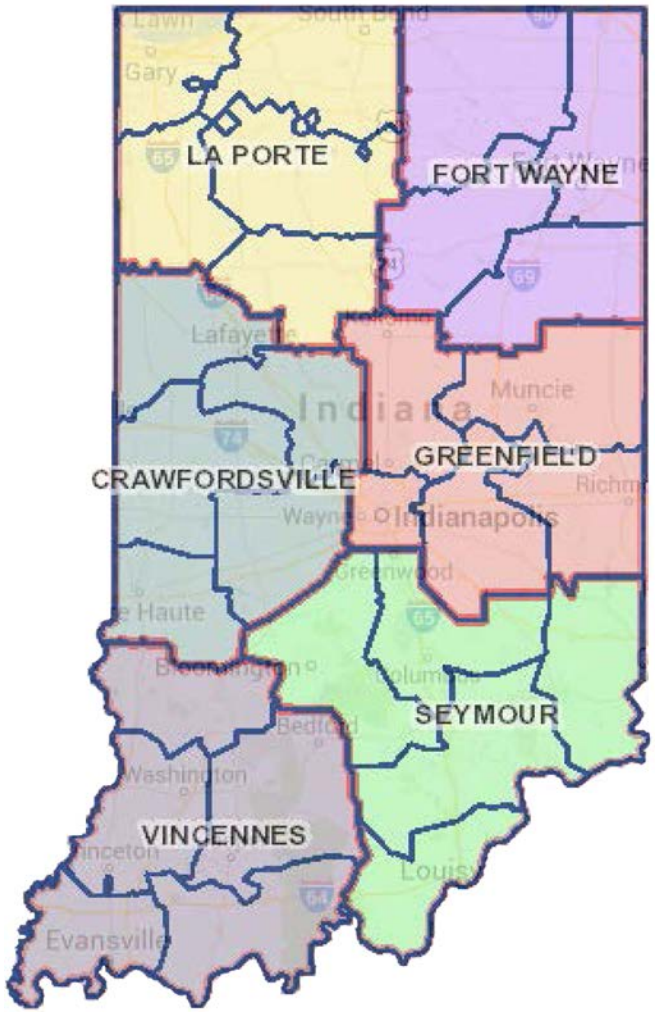
INDOT FY 201516 GOALS

- 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



INDOT VALUES

INI

The Value of Values

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.

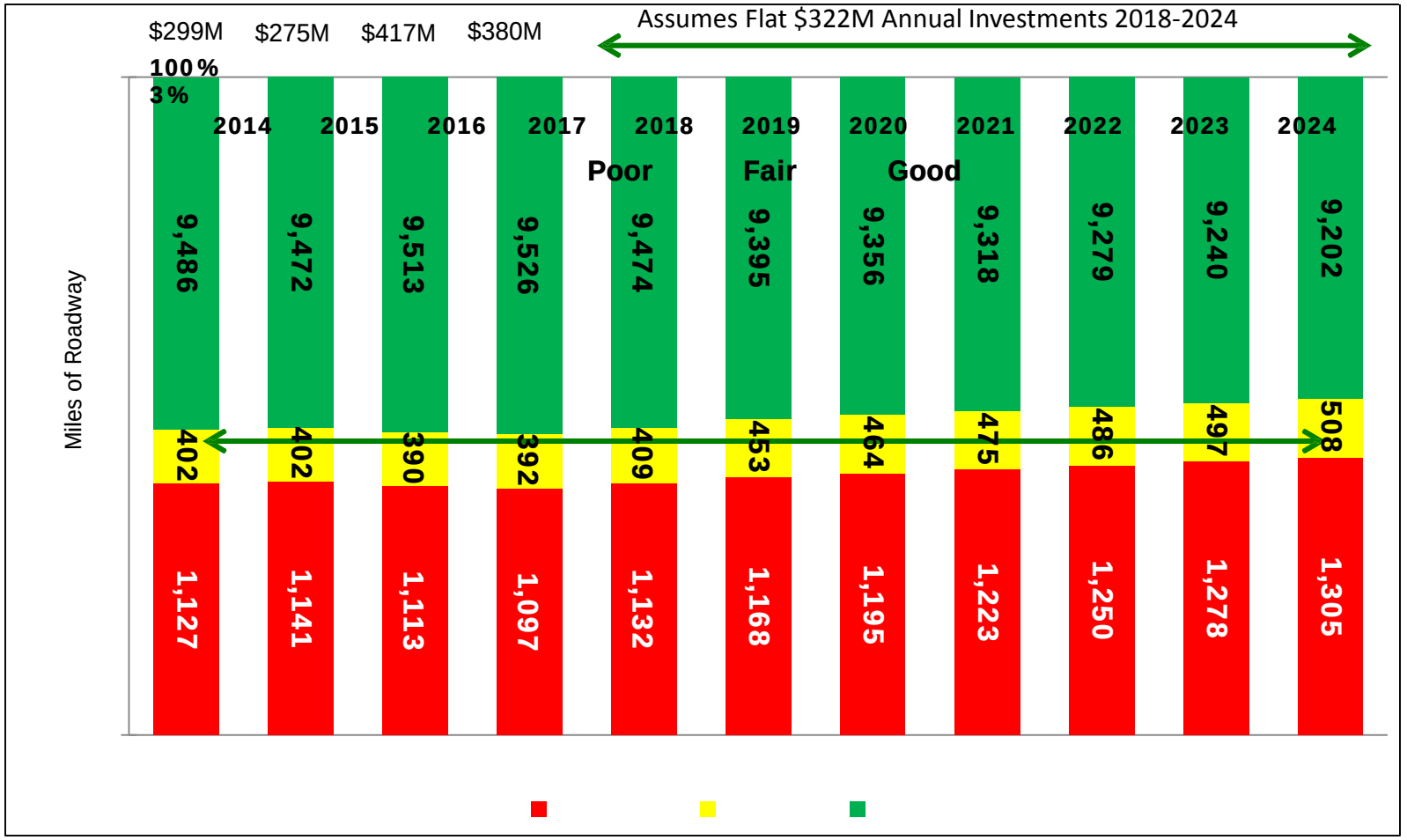
3. Accountability — Take personal responsibility for actions and decisions.

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.

RESULTS: ROADWAYS

Pavement Surface Conditions Over 10-Years for Current Funding Trends



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

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

ROADWAYS: PRIORITIES

Current Service Level

11.4% Poor in 2024

10-Years

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

INDOT's Target Service Level

≤7.5 % Poor in 2024

10-Years

$498M Annual Investment
826 Miles of Poor Pavement

INDOT's Recommended Service Level

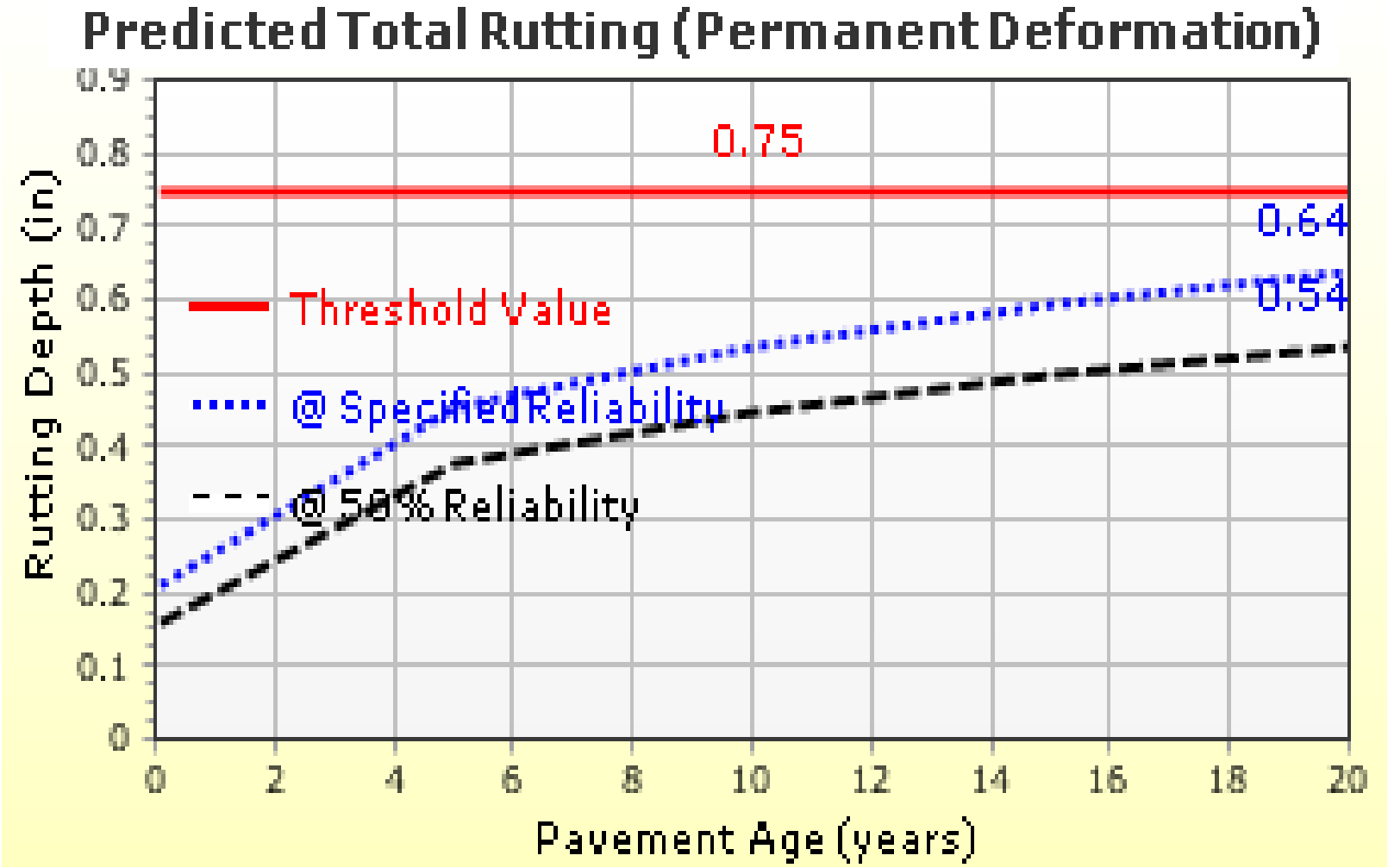
≤4.75 % Poor in 2034

20-Years

$561M Annual Investment
533 Miles of Poor Pavement

What is the acceptable result for the taxpayer?

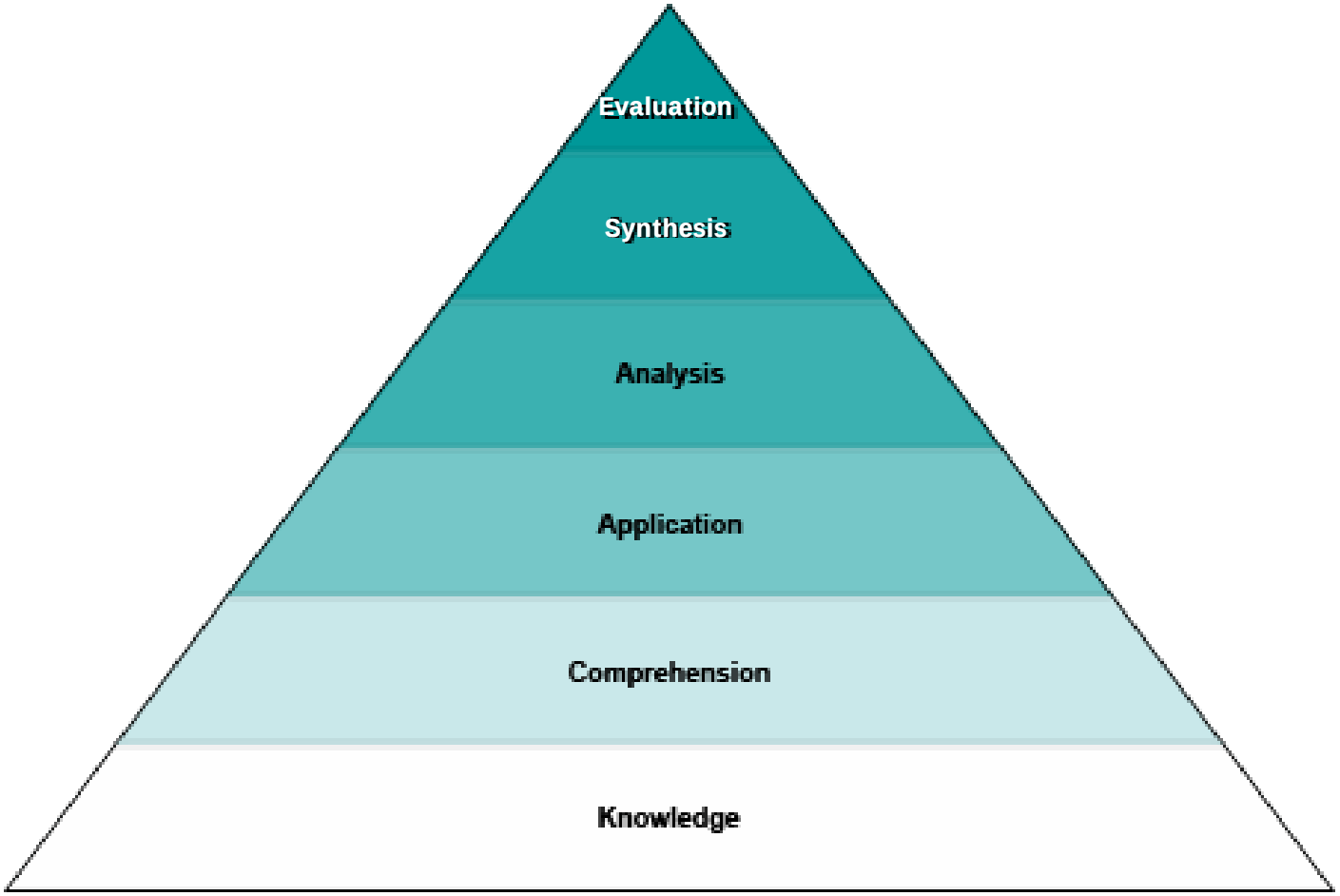
Time to failure Distress levels



Owner's Considerations

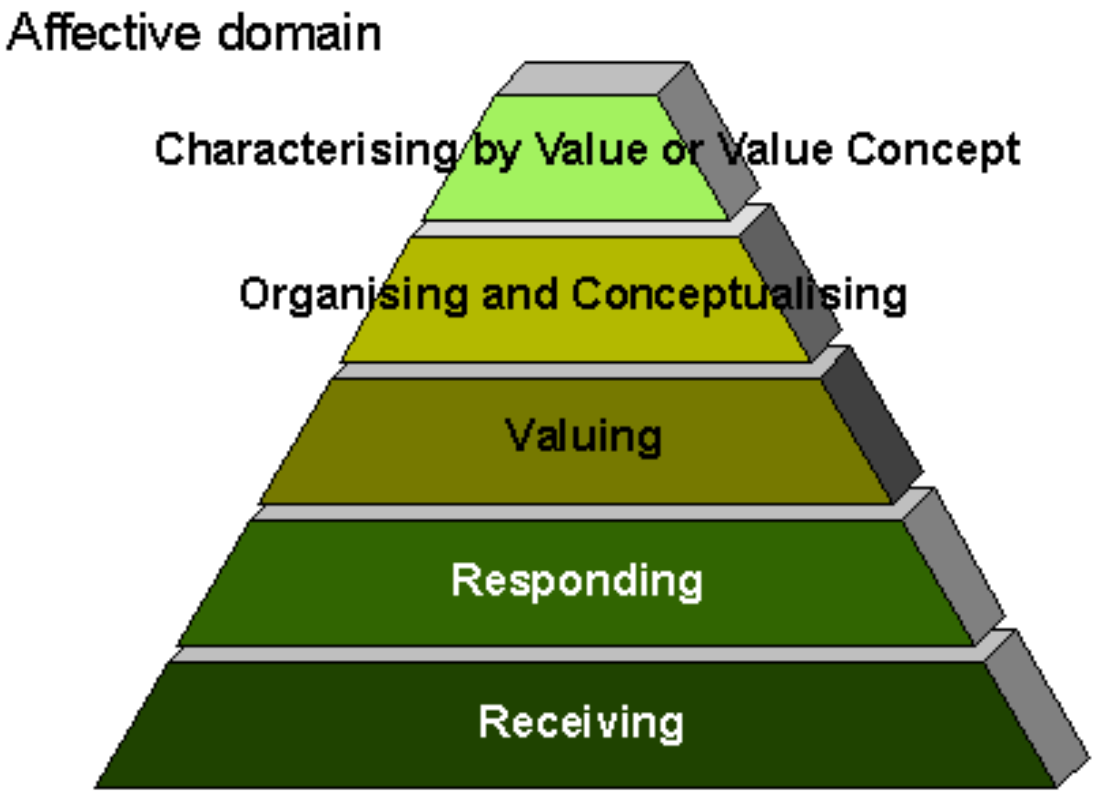
- Informed Owner's Considerations
  - What We Want:
    - Best Service Life/Cost ratio
    - Acceptable Service Level
    - Least Cost to Own/Operate

Intellectual Construct



Bloom's Taxonomy of learning. Adapted from: Bloom, B.S. (Ed.) (1956) Taxonomy of educational objectives: The classification of educational goals. Handbook I, cognitive domain. New York ; Toronto: Longmans, Green.

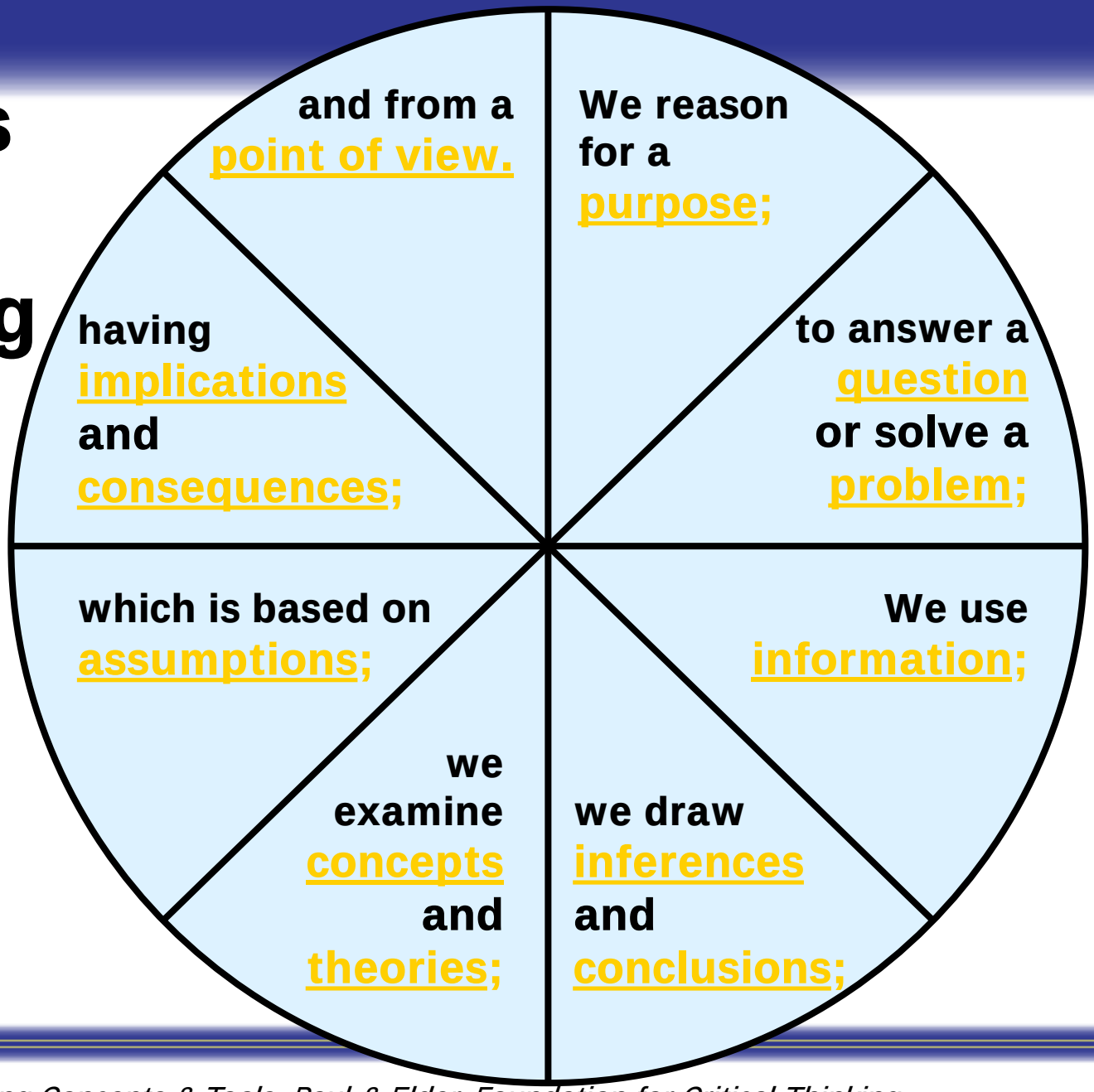
Intellectual Construct



Atherton J S (2011) *Learning and Teaching; Bloom's taxonomy* [On-line: UK] retrieved 27 February 2013 from http://www.learningandteaching.info/learning/bloomtax.htm

Elements of Reasoning

Taking thinking apart . . .



Critical Reasoning Concepts & Tools, Paul & Elder, Foundation for Critical Thinking

Universal Intellectual Standards

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

Testing the quality of your thinking. .

.

A good start…

What standards might you add for your discipline?

Project Situation & Business Case

- 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

Original General Plan & C&S Alt

- 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

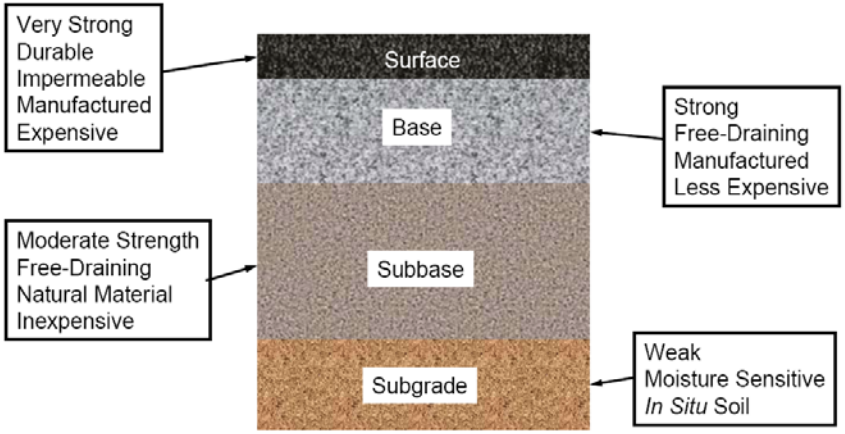
- Field evaluation-Existing pavement pictures
- Core Report
- FWD Report
- Pavement Management data
- Old contracts review

Geotech-Pavement Assessment

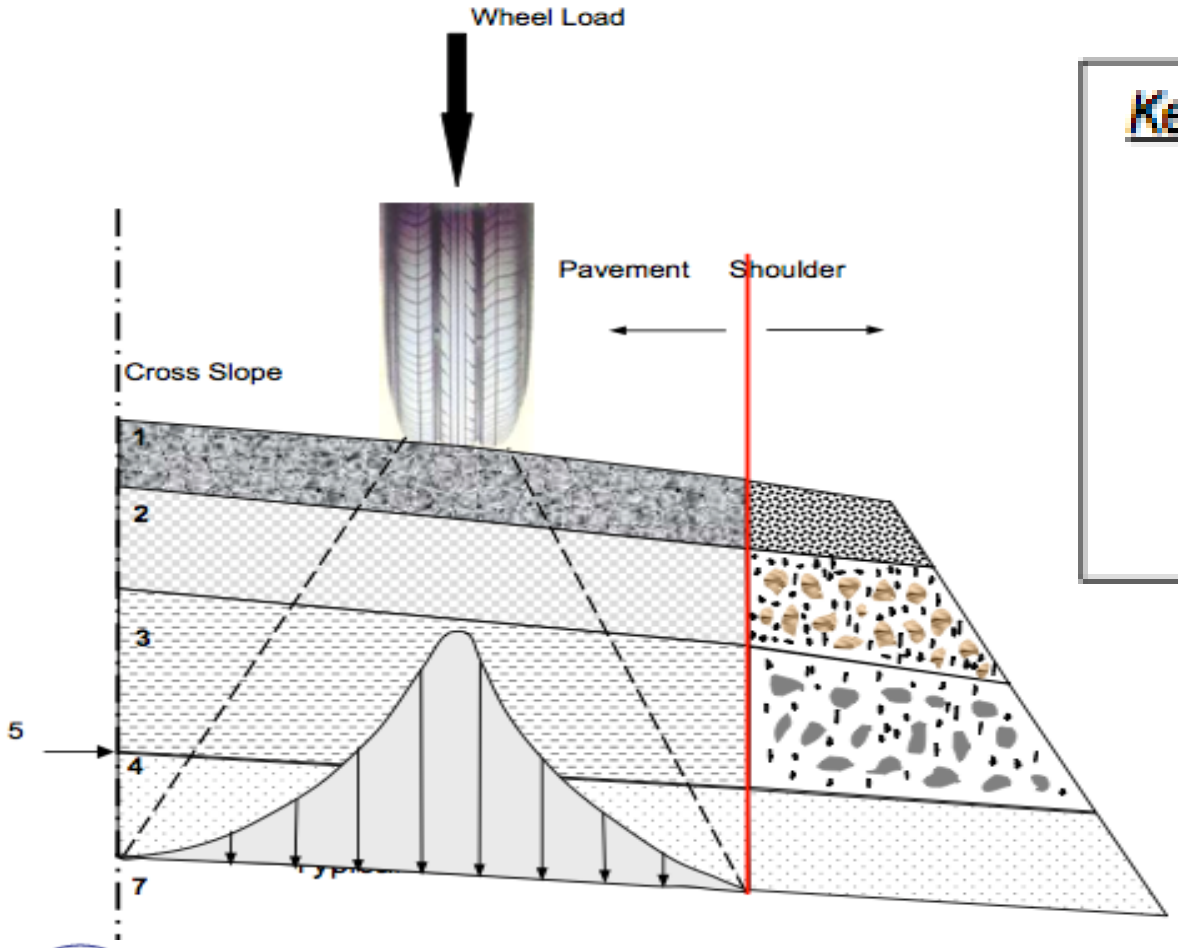
- Geotechnical Involvement general information point
  - Historically, geotechnical “error” is reportedly one of the reasons/drivers of large and expensive AoCs (advice of changes)
    - i.e., CHANGE ORDERS that bust project budgets
- How do we change that?

Structural Design

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



Definitions – Flexible Pavement



Key:

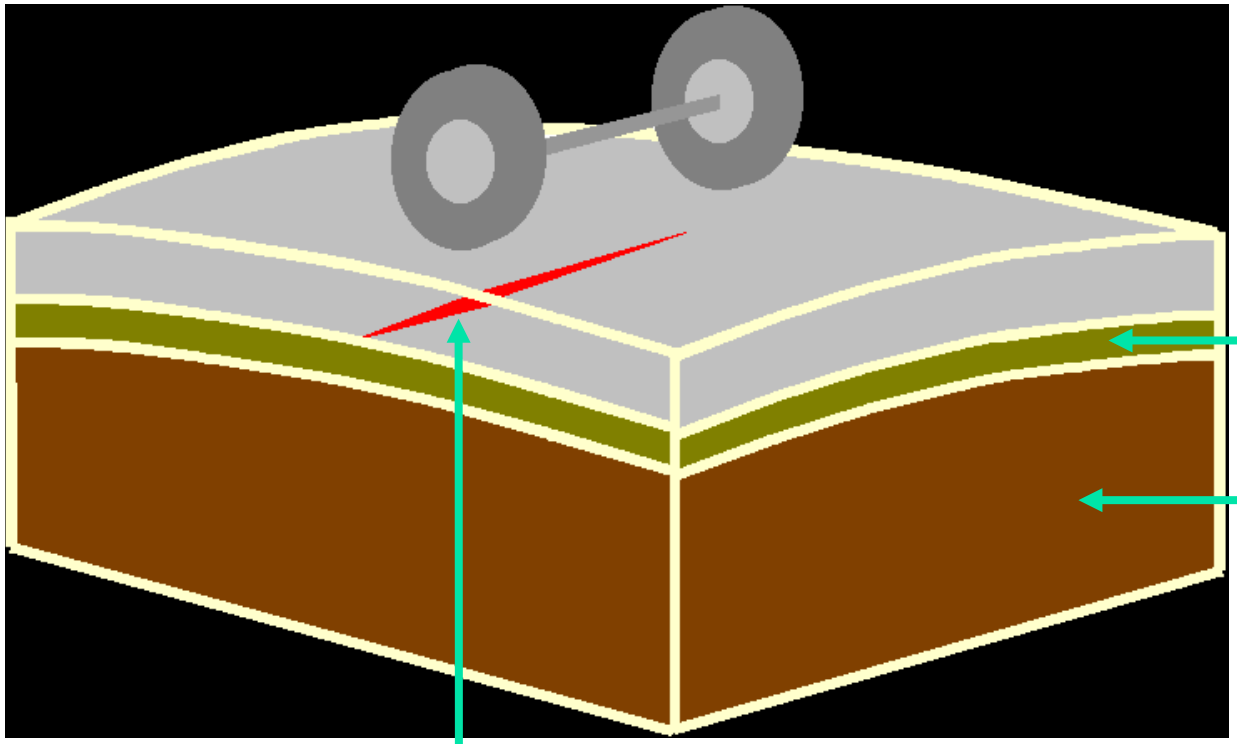
1: A.C. surface course
2: base
3: sub base
4: compacted road
5: subgrade
6: concrete surface
7: roadbed

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

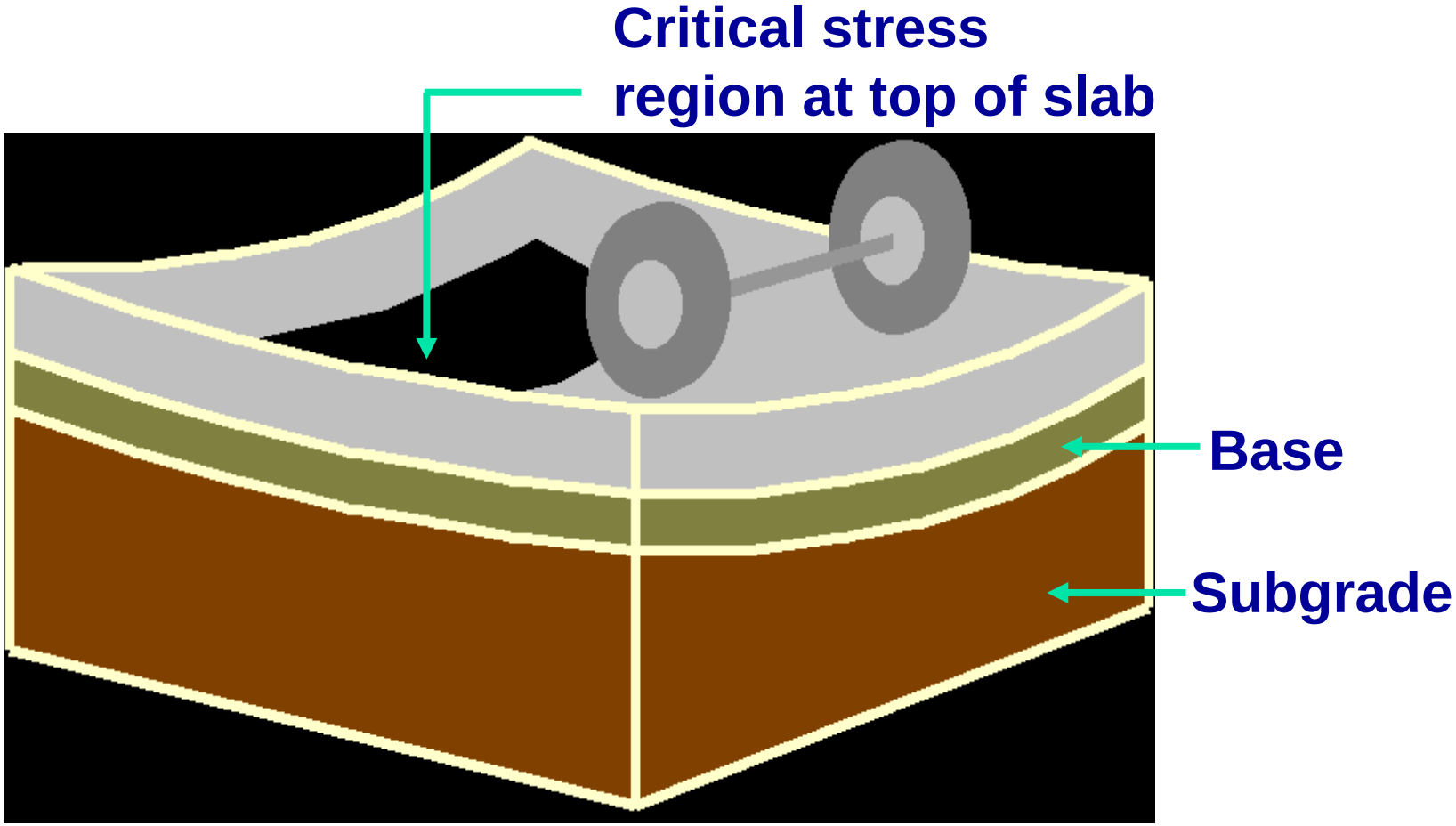
JPCP Bottom-Up Cracking –

(Mid-slab Load + Positive Curl/Warp Condition)

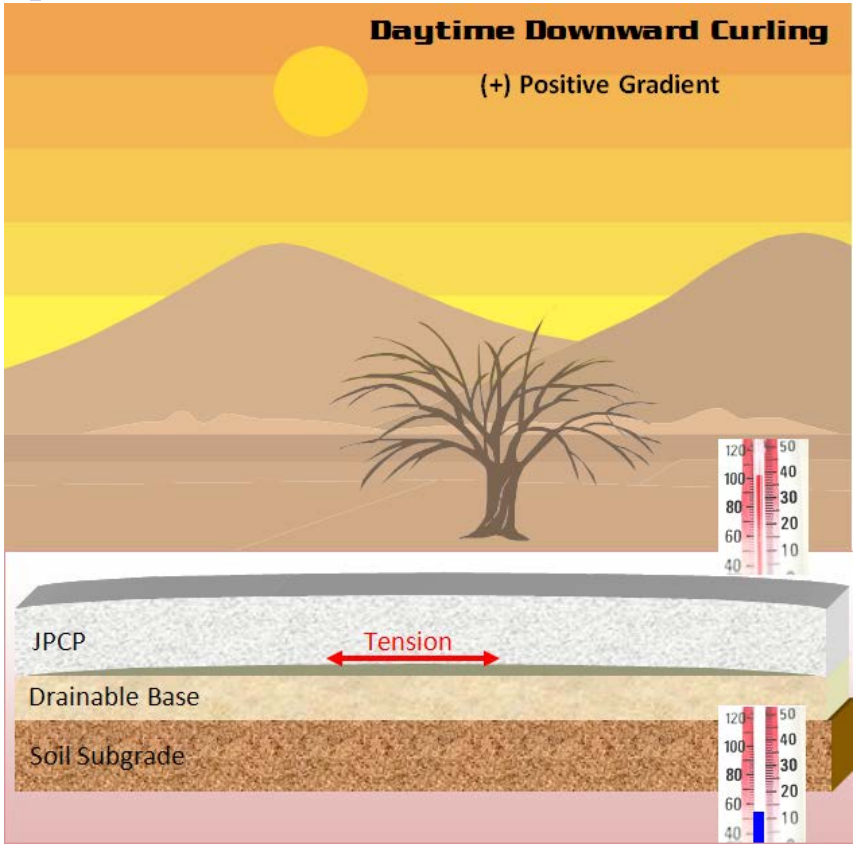


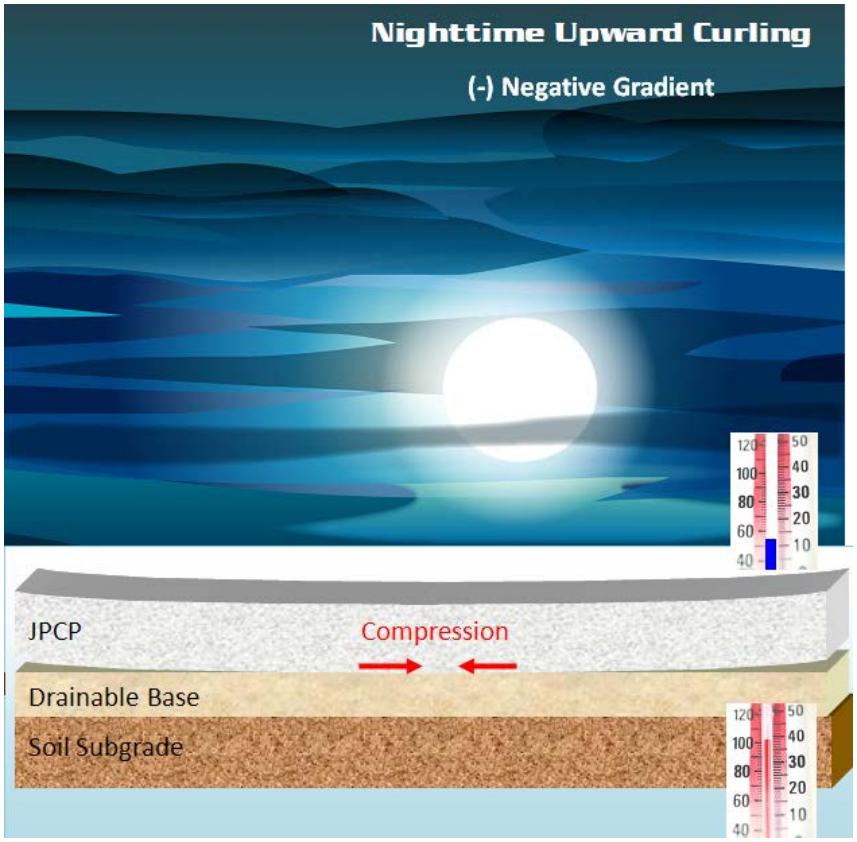
JPCP Top Down Cracking

(Joint Load + Negative Curl/Warp Condition)



Stress and strain in rigid pavement – Curling stress





JPCP cross section

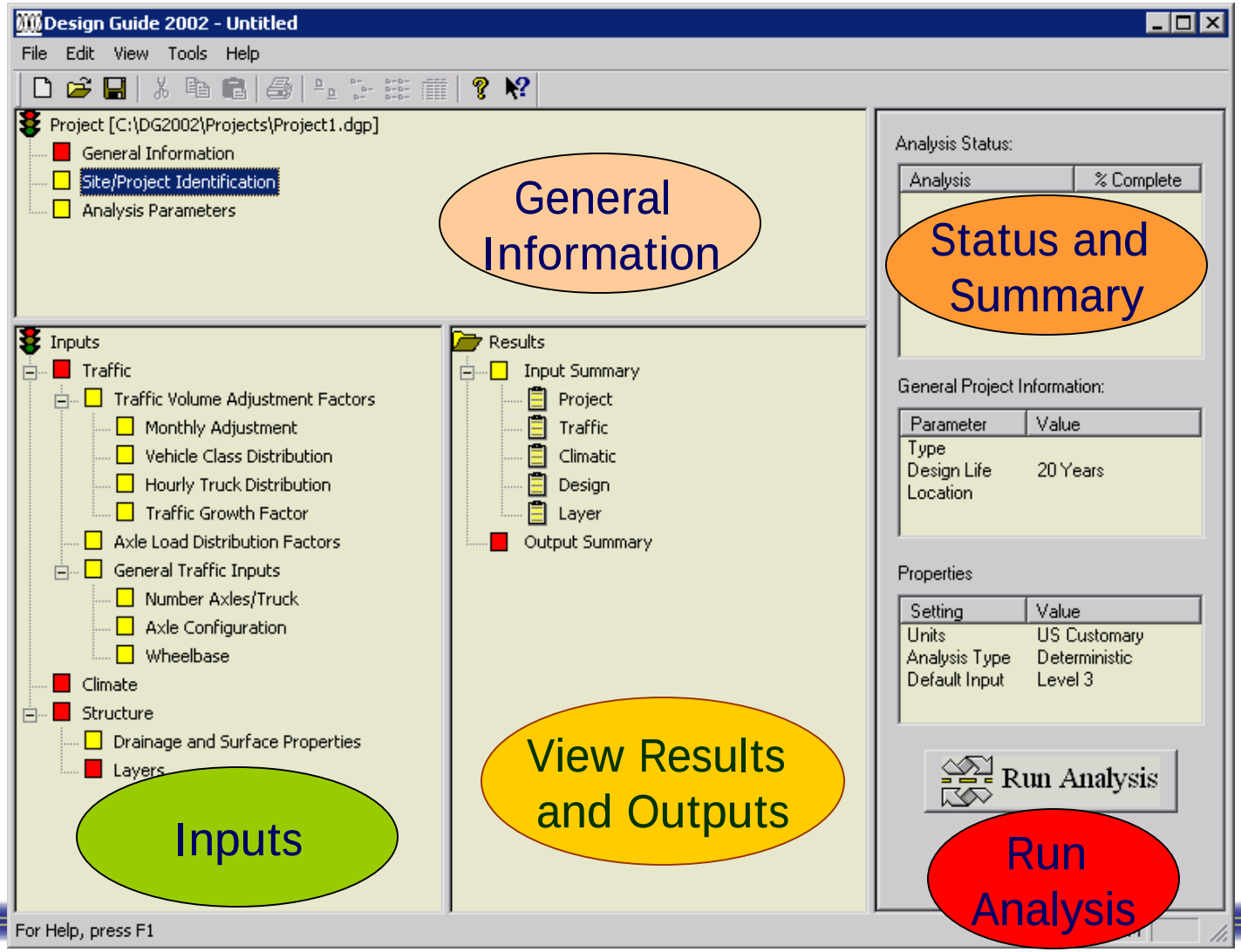
- 11” – 13” JPCP
- 3” Open graded stone
- 6” - 12” Dense graded stone
- 14” Soil treatment
- Soil subgrade
- Foundation Soil

Overview of MEPDG Software

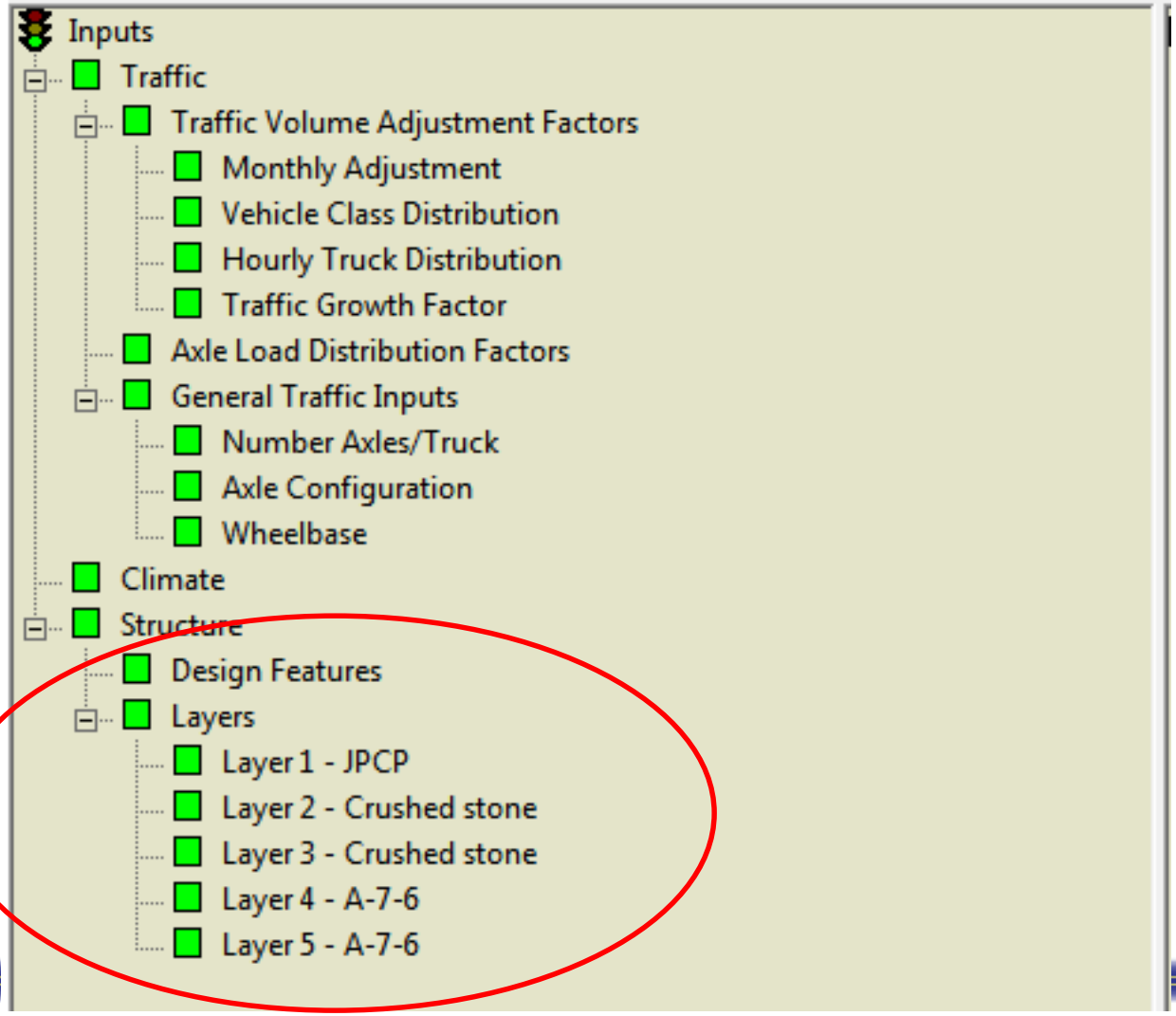
http://www.trb.org/mepdg/software.htm

(Search for *MEPDG software*)

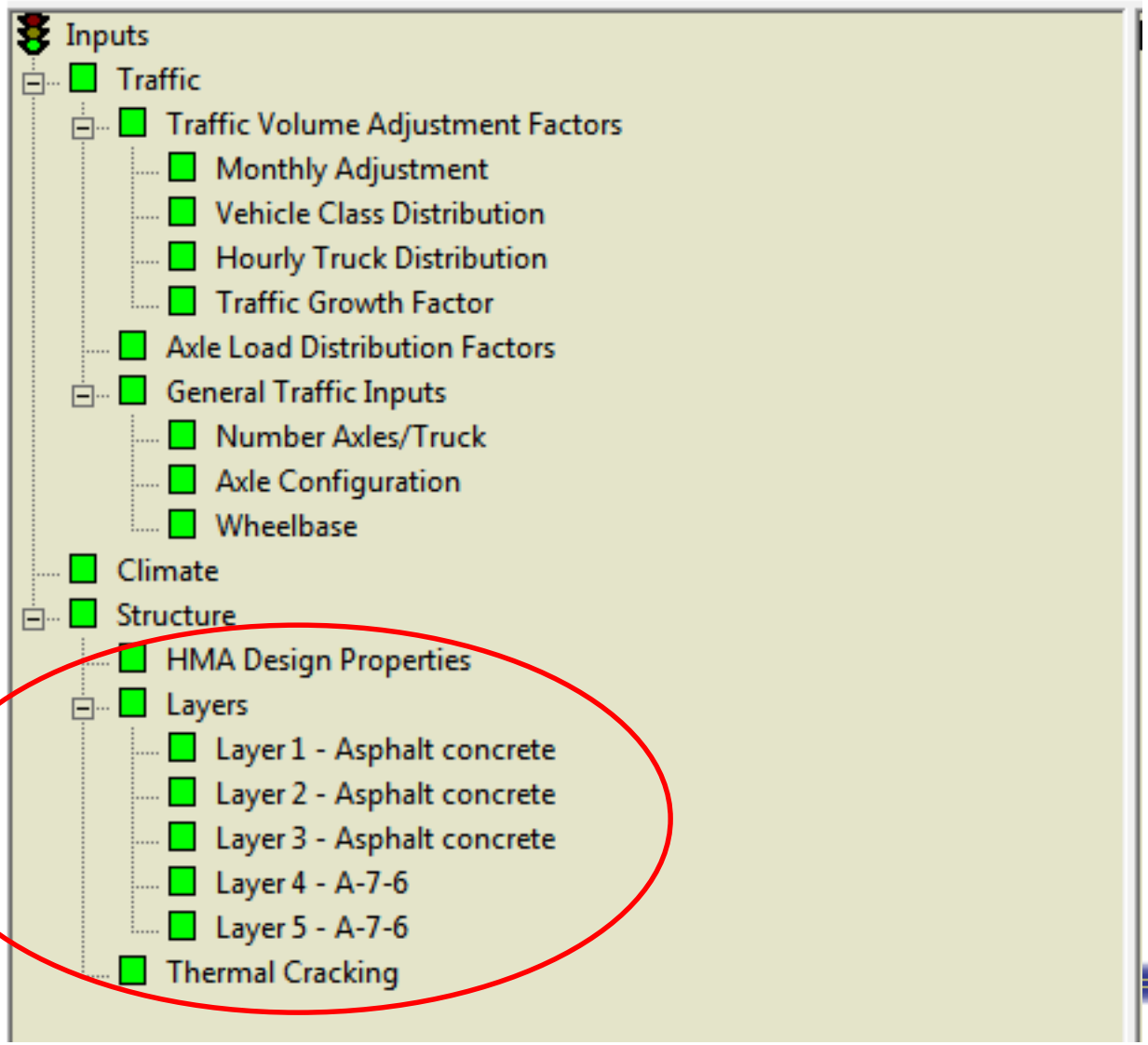
Main project screen



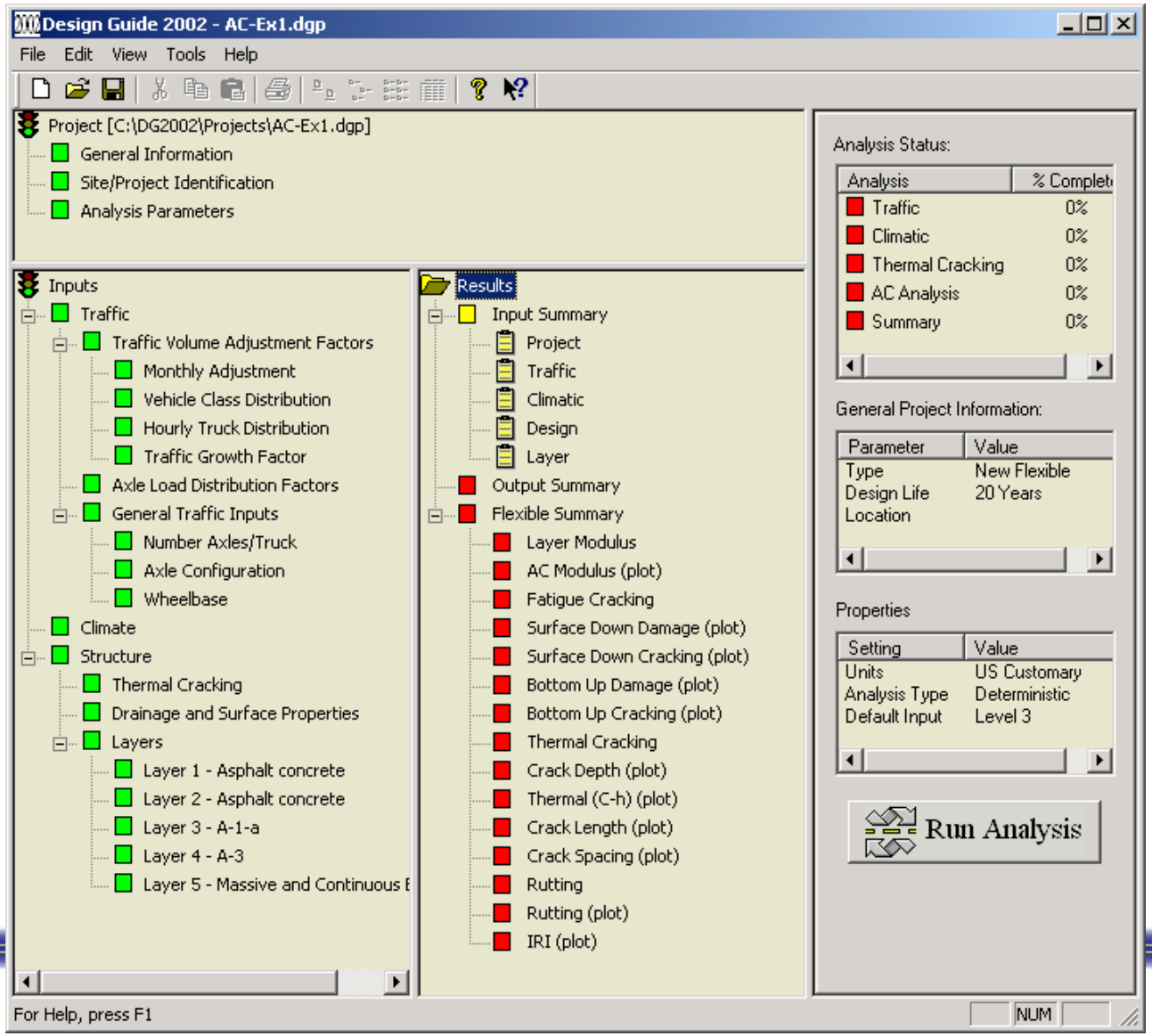
JPCP design features, layers, and material properties



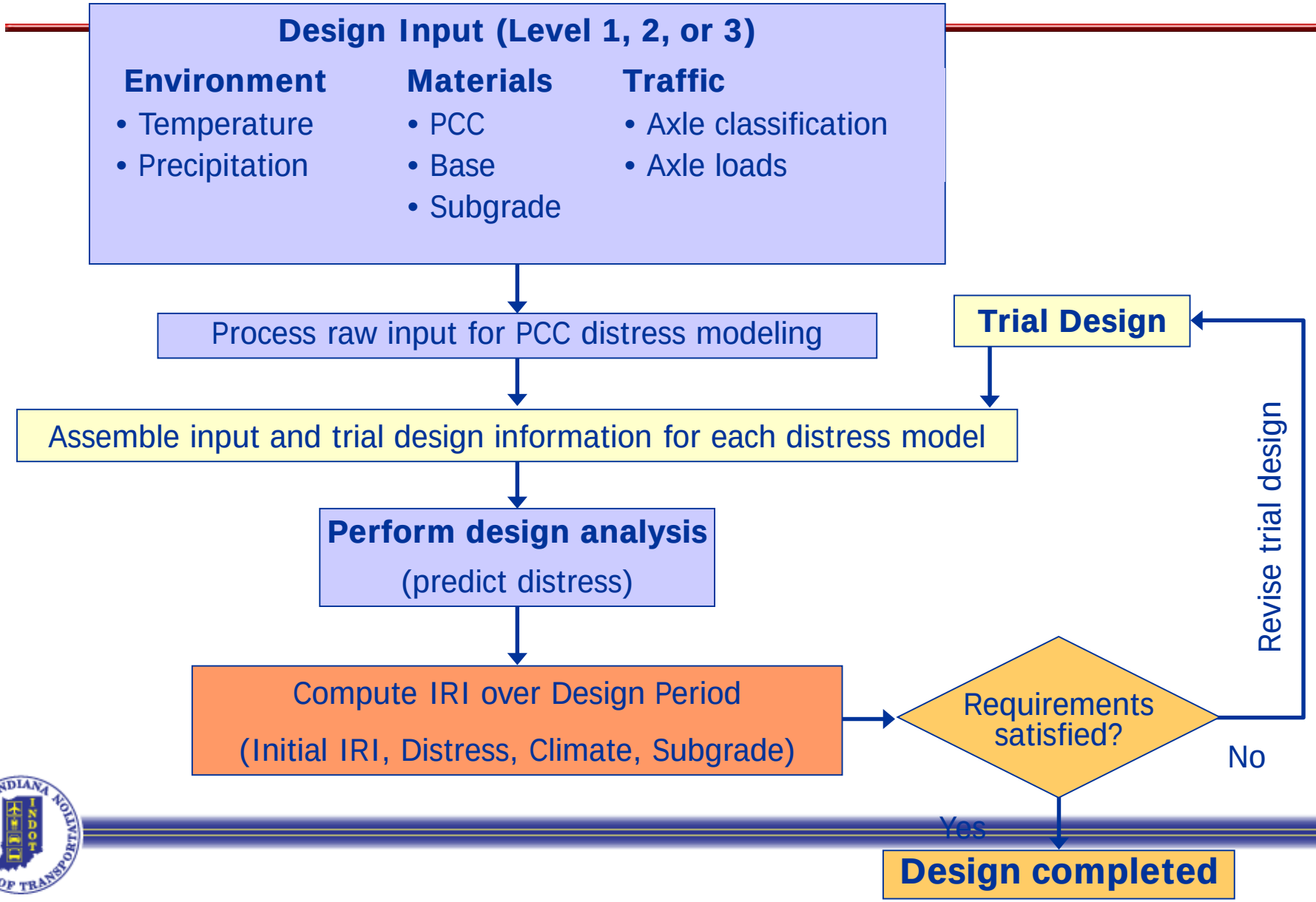
HMA design properties, layers, and thermal cracking



Run analysis



Design process



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

Management Strategic Direction

- 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

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

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

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?

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

Management Strategic Direction

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

Management Strategic Direction

- 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

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

Current Pavement Asset

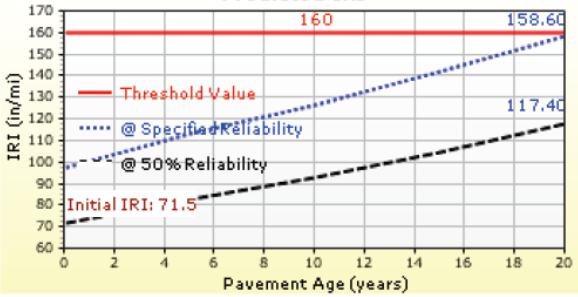
- Problem assessment and statement
- Possible solutions
  - Treatment options
- COA screening and evaluation
  - Worst first worst, but necessary
  - Engineering economics intervention point optimization
  - Temporary bridging strategy or approach

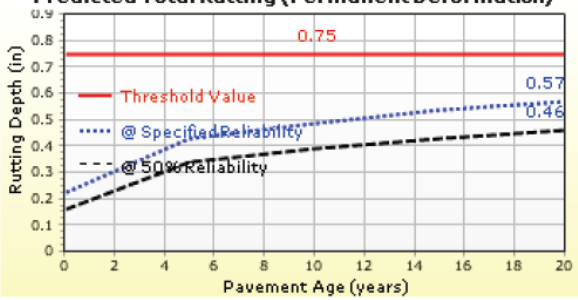
Management Practice

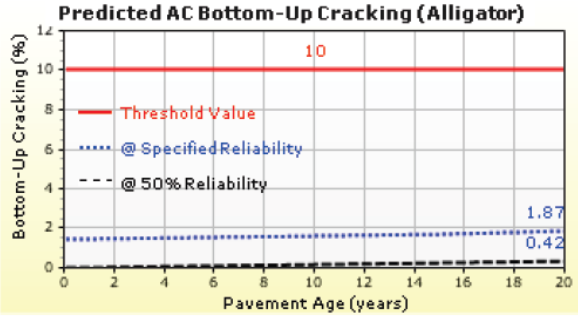
- Mechanistic-Empirical Pavement Design Guide (M-EPDG) philosophy

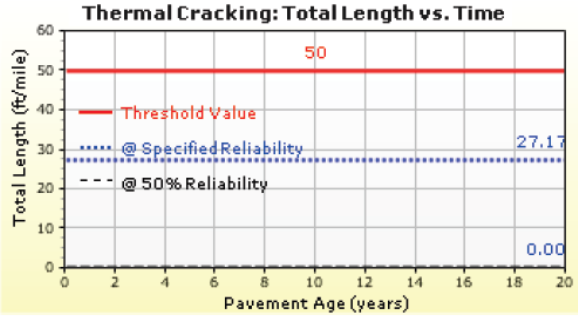
Permanent deformation - AC only (in.)	0.40	0.18	90.00	100.00	Pass

Distress Charts









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Approved by: on: 8/24/2012 10:52 AM

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Current Pavement Asset Management Practice

- 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

General Chap 304 Outline

Comprehensive Pavement Analysis

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

Cont…

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

Cont…

Comprehensive Pavement Analysis

- Life Cycle Cost Analysis
- Typical Pavement Sections
- Pavement Design Request and Instructions

Introduction

It provide guidance for:

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

For public roadway system in Indiana

History

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

History

NHS were built with different Typical

Concrete with 9-7-9 inch thick

18-20 feet wide

Tilt sections

overlayed & widened with HMA

History

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 owenership
- 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 reclamation

Cont.....

- Preventive Maintenance
  - Surface treatment
  - HMA mill & fill
  - In-place recycling
    - HIP
    - CIP
    - FDR

Pavement Type Selection

Based on specific project considerations:

- Project scope
- LCCA
  - >10000 yd2
  - >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


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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

MEPDG is a iterative process

Outputs are pavement distresses and not tk

Trial design based on performance criteria
Level 1, 2, 3
Performance criteria for flexible pavement
- Roughness(IRI)
- Rutting
- Transverse cracking
- Fatigue cracking

MEPDG cont…

Performance criteria for Rigid Pavement

- Roughness(IRI)
- Faulting
- Cracking

MEPDG cont..

MEPDG design Considerations

- Foundation/Subgarde
- Existing pavement condition
- Paving material
- Construction factors
- Environmental factors
- Traffic loading
- Subdarinage
- Shoulder design
- Rehabilitation treatment & strategies

MEPDG

Lisa Egler-Kellems
Demostrates AASHTOWare PavementME©

HMA Pavements & Pay Items

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 Pavements & Pay Items

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

Subgrade Treatment

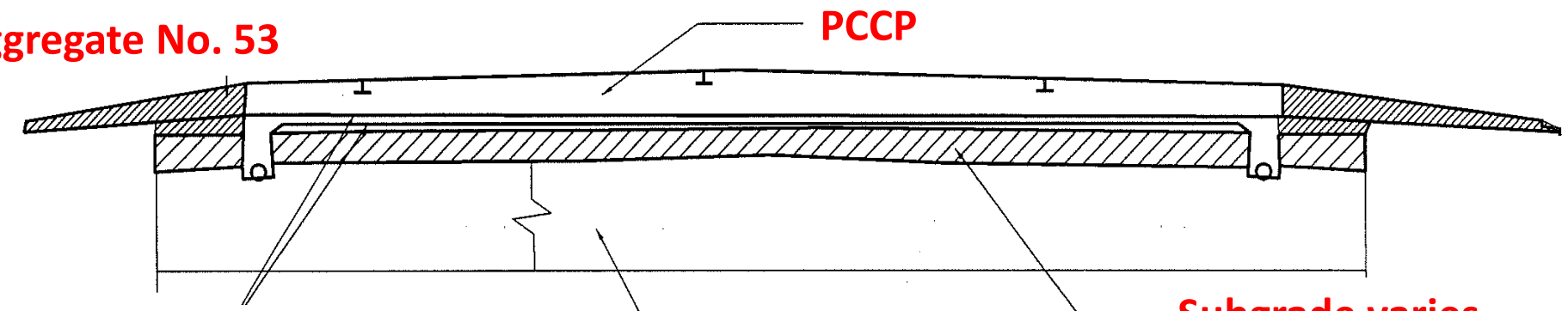
IN Design Manual Sect. 304-14.05

Subgrade Material:

- Prepared Subgrade layer
- Natural Subgrade layer

Function is to provide the foundation to the pavement.

Pavement, Subgrade & It's Foundation Section

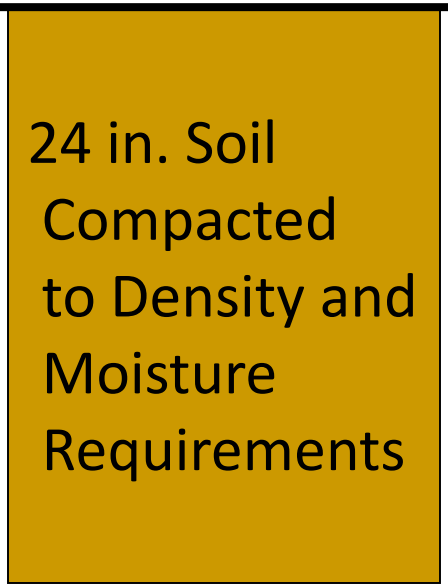


Subgrade Types

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



Road Description	Type of Work	Subgrade Length	Maximum Design M_R
CR/SR	New Road, Road Reconstruction and > 6 feet Widening	> 800 feet	M_R = 6,000 psi

Con't.

Type 1B

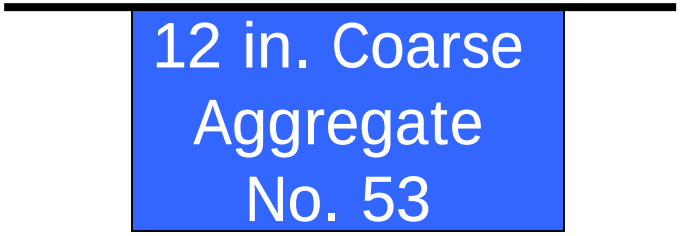
14 in. chemical soil modification

Road Description	Type of Work	Subgrade Length	Maximum Design M_R
CR/SR/US/I	New Road, Road Reconstruction and > 6 feet Widening	> 800 feet	M_R = 9,500 psi

Con't.

Type 1C

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



Road Description	Type of Work	Subgrade Length	Maximum Design M_R
CR/SR/US/I	New Road, Road Reconstruction and > 6 feet Widening OR Reconstruction or Widening < 6 feet	< OR > 800 feet	M_R = 9,500 psi

Con't.

Type II

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

Road Description	Type of Work	Subgrade Length	Maximum Design M_R
SR/US	Road Reconstruction or < 6 feet Widening	> Or < 800 feet	M_R = 6,000 psi

Con't.

Type IIA

8 in. chemical soil modification

Road Description	Type of Work	Subgrade Length	Maximum Design M_R
SR/CR	New Road, Road Reconstruction and > 6 feet Widening	> 800 feet	M_R = 6,000 psi

Con't.

Type III

6 in. of soil compacted to the density and moisture requirements

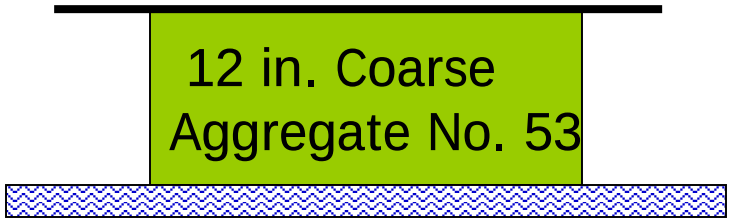
6 in. Soil Compacted to Moisture Density Requirements

Road Description	Type of Work	Subgrade Length	Maximum Design M_R
CR/or other local roads	Road Reconstruction or Widening	< 800 feet	M_R = 4,500 psi

Con't.

Type IV

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



Geogrid Type IB

Road Description	Type of Work	Subgrade Length	Maximum Design M_R
CR/US/SR/LS/I	Reconstruction and < 6 feet Widening	> 800 feet	M_R = 9,500 psi

Con't.

Type V

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

3 in. Coarse Aggregate No. 53

Subgrade Treatment for Trails on Abandoned-Railroad Corridor

Road Description	Type of Work	Subgrade Length	Maximum Design M_R
Bike Paths/Trails	Reconstruction or Widening	----------	M_R = 4,500 psi

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.

- Unit weight of stabilized material
- Resilient Modulus – Stabilized Mr value
- Thermal conductivity – Geotechnical report
- Heat Capacity - 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 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 $

Miscellaneous Pavement Project Elements

- 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

Underdrains

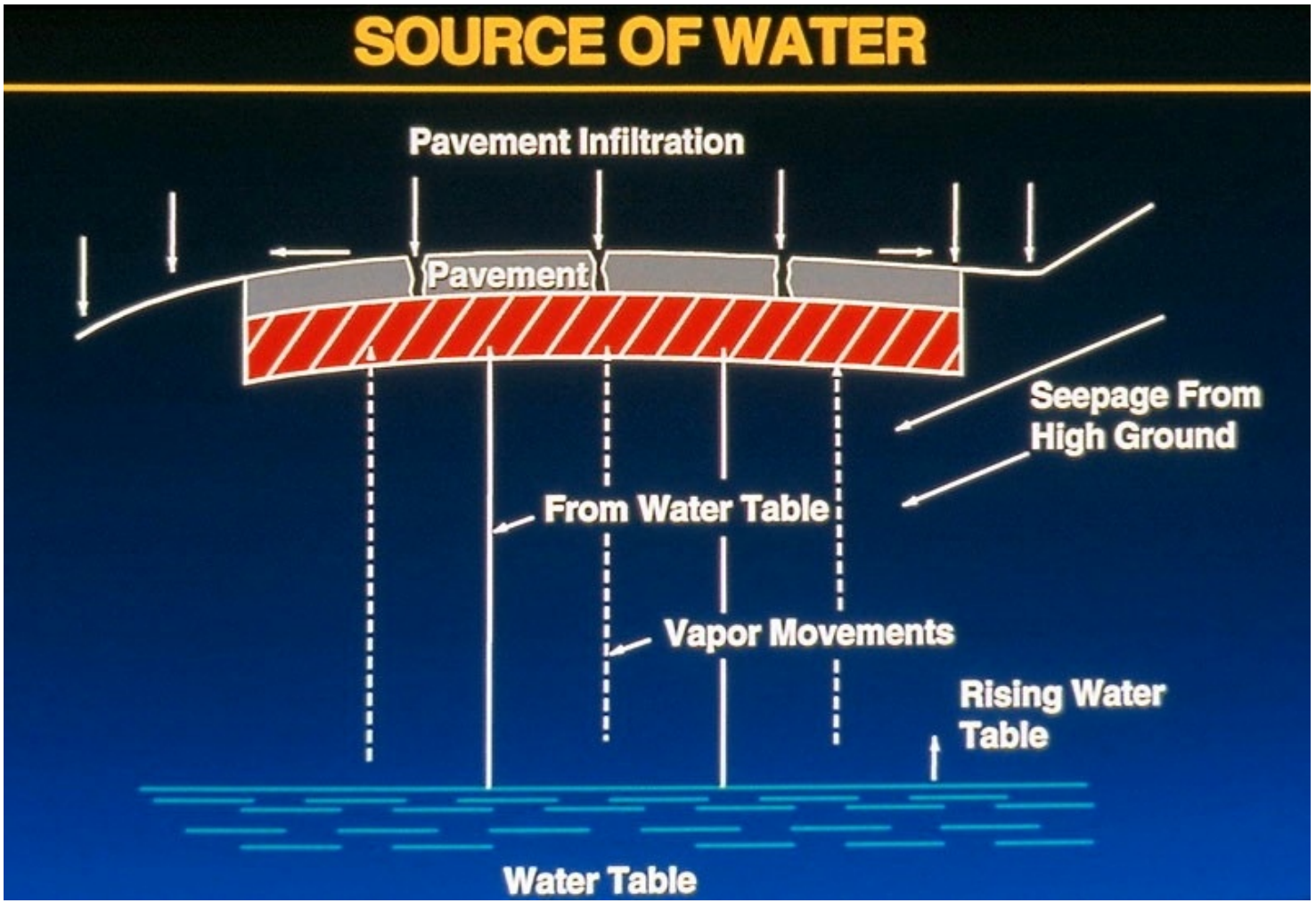
Purpose: Remove water from the subgrade and pavement structure

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.


SOURCE OF WATER
Pavement Infiltration
Pavement
Seepage From
High Ground
From Water Table
Vapor Movements
Rising Water
Table
Water Table


DODGE


37
144

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

Preventive Maintenance cont…

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

Preventive Maintenance cont…

PCCP PM Treatments:

- Surface profiling
- Partial Depth Patching
- Full Depth Patching
- Underseal
- Slab Jacking
- Stitching

LCCA

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” JPCP
- 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?