Pavement Design for In-Place Recycling

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Outline

- Purpose of pavement design
- Pavement evaluation
- Pavement design procedures
- Material characteristics
- Structural coefficients
- Example structures
- Summary and conclusions

Purpose of Pavement Design

- Evaluate the existing pavement to determine the viability for the in-place recycling process
  - Input needed for design
  - Assess the pavement for equipment support (i.e. CIR train)
- Determine LCCA options
- Determine the thickness of recycled layers and overlay, if needed

Pavement Evaluation Options

- Coring
  - Visual evaluation of layers
  - Needed for mix design
  - Delaminated / stripped layers
  - Dynamic cone penetrometer option

- Non-destructive testing
  - Deflection testing
    - Falling weight deflectometer (FWD)
    - Dynaflect
  - Ground penetrating Radar (GPR)

Material characteristics

- HMA industry tests have been adapted for bituminous CIR and FDR mix designs (Raveling or cohesion for early strength gain)
- Bituminous CIR and FDR have slightly lower modulus than HMA
  - Cement FDR acts like a weak PCC
  - Mechanical FDR behaves like granular base

Material characteristics

Typical quantities

- CIR - 1.5 to 3.5% emulsion (65% residue)
- FDR
  - 3 to 6% emulsified asphalt
  - 1 to 3% foamed asphalt
  - 3 to 6% cement
- Air voids 9 to 14%

Scope of treatments

- CIR
  - Preservation product with some structural improvement
  - Leaves a portion of existing asphalt pavement in place
  - Does not treat the base or subgrade
- FDR
  - Of the three treatments, has the most structural improvement
  - Treats the entire depth of asphalt pavement
  - Possibly treats the subgrade

Pavement design

The pavement structure – depth of recycling and overlay thickness – is primarily influenced by:

- Traffic – especially trucks (ESALs)
- Subgrade (effective modulus)
- Aggregate base or stabilized base thickness, type, and quality / condition (structural coefficients, thickness, drainage coefficients)
- Climate (effect on modulus values)
- Design life (effect on ESALs)

Pavement design procedures

- 1993 AASHTO Guide for the Design of Pavement Structures
  - Rehabilitation design
- Mechanistic Empirical Pavement Design Guide
  - NCHRP study underway for CIR and FDR

AASHTO Rehabilitation Design

$SN_{OL+\underline{CIR/FDR}} = SN_f - SN_{eff}$

- $SN_{OL+CIR/FDR} = a_{OL}D_{OL} + a_{CIR}D_{CIR}$ (Solve for overlay thickness)
- SN_f = AASHTO Sec. II, Fig. 3.1
- $SN_{eff} = a_{AC}D_{AC} + a_2D_2m_2 + a_3D_3m_3$
    - Condition data - subjective
    - Some of HMA is removed for CIR and all is removed for FDR

Rehabilitation Example (FDR)

2-lane road, 3500 AADT and 10% trucks; effective subgrade modulus = 6000 psi. Existing 5” HMA over 6” aggregate base. Pre-mill 3”

- SN_f = 3.90 (AASHTO Sec. II, Fig. 3.1)
- SN_{eff} = 2 x 0.11 = 0.22 (remaining base after milling and FDR based on condition data)
- $SN_{OL+FDR} = SN_f – SN_{eff} = 3.90 – 0.22 = 3.68$
- $SN_{OL+FDR} = 3.68 = a_{OL}D_{OL} + a_{FDR}D_{FDR}$
- 3.68 = 0.44 x 5 + 0.25 x 6
- Final structure – 5” HMA over 6” FDR over 2” remaining aggregate base

Surface course types over CIR and FDR

- WMA / HMA binder and wearing courses
- Rubberized asphalt concrete
- Ultra-thin bonded wearing course
- Surface treatments – micro surfacing or chip seal, etc.
- Dense-graded cold mixes

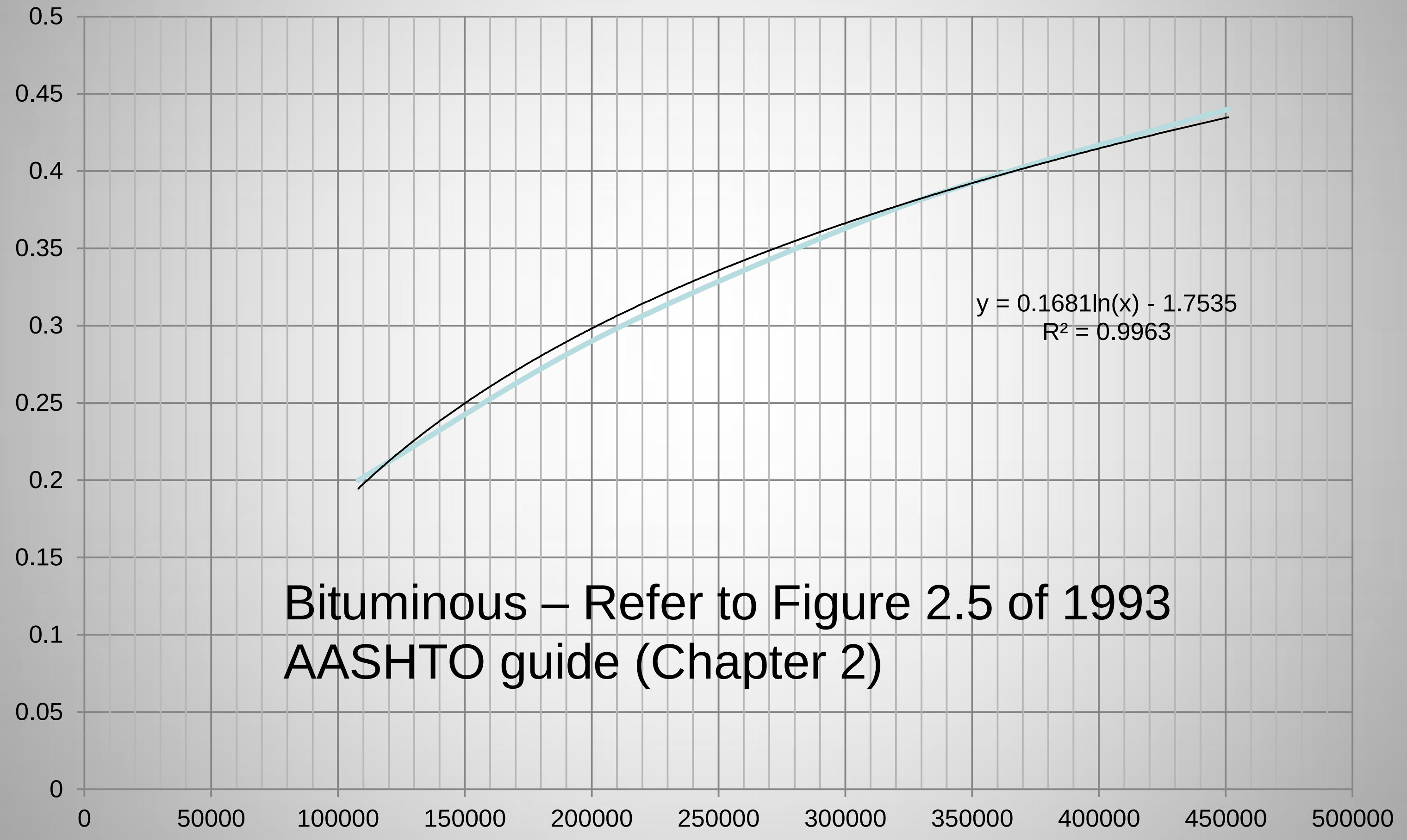
The recycled layer must be covered by at least a bituminous treatment (i.e. micro surfacing or chip seal). The specific treatment needed will depend on pavement design and ride expectations.

Structural coefficients for 1993 AASHTO Design

Treatment (and thickness)	AASHTO coefficient range
HMA	0.40 – 0.44
Aggregate base (6-14”)	0.10 – 0.12
Mechanical FDR (6-12”)	0.10 – 0.12
Bituminous FDR (4-8”)	0.20 – 0.28 (0.25)
Chemical FDR (8-12”)	0.14 – 0.23
CIR (2-5”)	0.28 – 0.33 (0.30)

Dependent on agency design philosophy and experience, quality of materials, and stabilizer type and amount

Structural coefficients

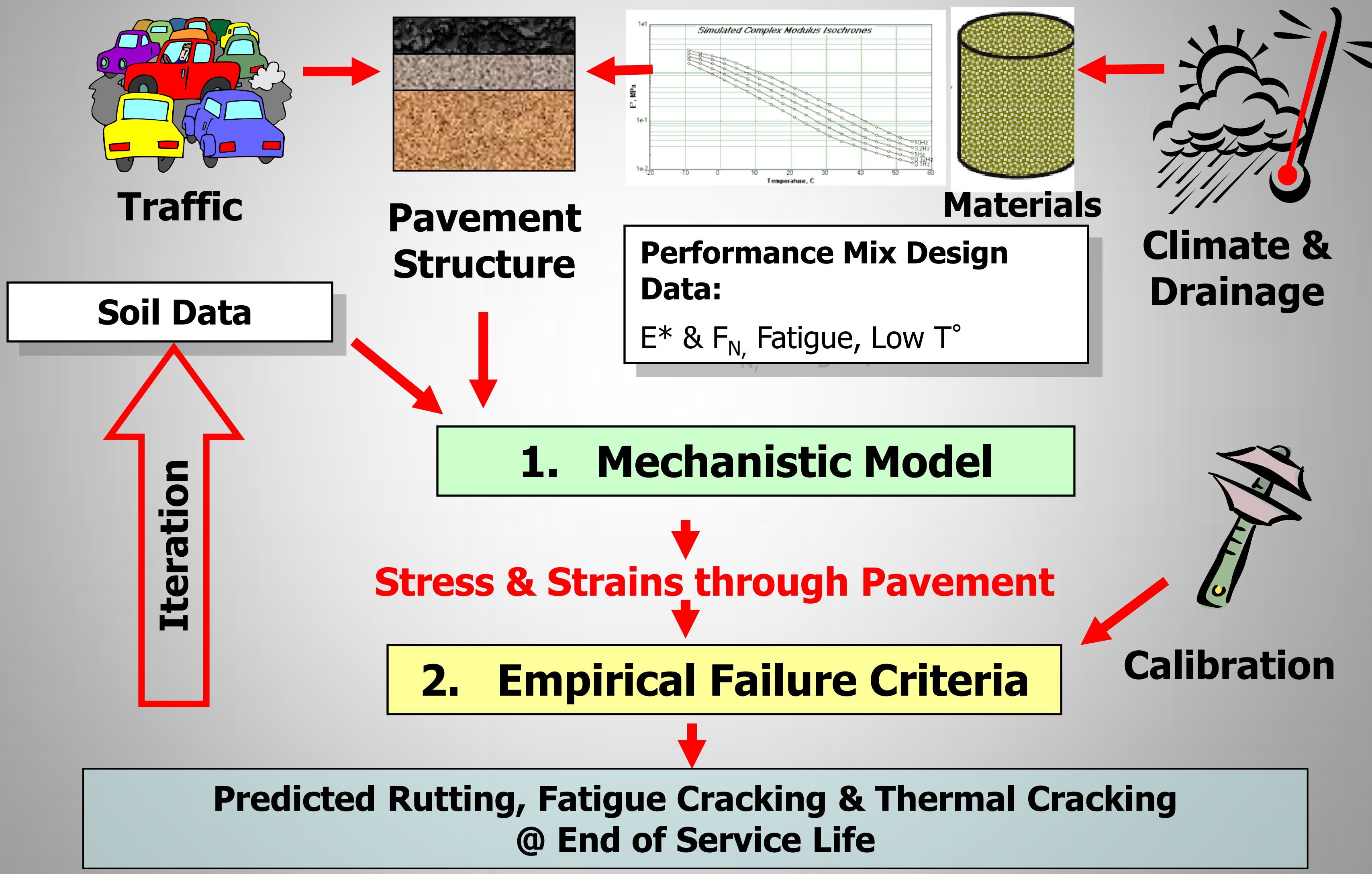


Bituminous – Refer to Figure 2.5 of 1993 AASHTO guide (Chapter 2)

Resilient modulus

- ASTM D 7369
- Perform at 20C to use Fig. 2.5
- Use lab-prepared specimens or cores to verify

AASHTO Mechanistic Empirical Pavement Design



MEPDG Analysis Program

- Level 1 – Measured properties
- Level 2 – Estimated properties
- Level 3 – Default properties

- Inputs:
  - Traffic (not ESALs)
  - Nearest climate station
  - Seasonal modulus change of layers
  - Complex modulus of asphalt layers and recycle layers (new)
  - Binder data

CIR as-built examples

- Virginia I-81 (Augusta County) – left lane
  - 21,000 AADT and 28% trucks
  - Before: 12” HMA over 11” aggregate base
  - After: 4” new HMA over 5” CIR with foamed asphalt over remaining HMA over aggregate base
- Nevada DOT CIR designs
  - For Category 4 or 5 (< 1,600 ADT), 3” CIR with double chip seal
  - For Categories 1 to 3 (>1,600 ADT), calculate ESALs for CIR design. >10,000 ADT with overlay

CIR as-built examples

- Washington Road, Tazewell County, Illinois (2001)
  - Up to 4600 AADT and 15% trucks
  - Before: 12” HMA over 12” gravel base
  - After: 3” new HMA over 3” CIR with emulsified asphalt over 9” remaining HMA over base
- Maple Lake, MN Municipal Airport Taxiway
  - Average 57 aircraft / day (general aviation)
  - Before: 6” HMA on clay subgrade
  - After: 3” new asphalt over 3” CIR (with 25% aggregate added and emulsified asphalt)

FDR as-built examples

- Fairburn, Georgia
  - 4260 AADT, two lanes
  - Before: 4” HMA over 7” aggregate base
  - After: Widened road. 3.25” HMA over 6” FDR
- Washington Ave. in Las Vegas, NV
  - 15,000 AADT and 3% trucks. Curbed city street – 5 lanes
  - Before: 5” HMA over 15” aggregate base
  - After: Mill off old HMA. 5” new HMA over 6” FDR with emulsified asphalt over existing base

FDR as-built examples

- CR 52 in Long County, Georgia
  - 3,375 AADT and 15% trucks
  - Before: 1.25” HMA over 6” sand clay base
  - After: 1.5” new HMA over 6” FDR with cement over existing base
- Lancaster, California
  - Up to 5,900 AADT with 11% trucks
  - Before: 3” HMA over 6” aggregate base
  - After: 4.5” HMA over 4.5” FDR

Summary and Conclusions

- Evaluate the pavement carefully for design inputs
- Ensure proper project selection for treatment
  - In-place recycling evaluation cannot just be observed from visual observations
- Evaluate different pavement design alternatives and finalize choice
- Perform a mix design with a reliable method
- Training before the project and communication during the project
- Verify structural coefficient if new to the process

Resources

Valuable resources if more information is needed…

- 1993 AASHTO Guide for Design of Pavement Structures
- Recycling and Reclamation of Asphalt Pavements Using In-Place Methods, NCHRP Synthesis 421, 2011
- Recycling seminars
- Asphalt Recycling and Reclaiming Association – Basic Asphalt Recycling Manual
- www.arra.org

Thank You!

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