Pavement Design for In-Place Recycling

September 13, 2012

Western States Regional In-Place Recycling Conference

Todd Thomas, P.E., Colas Solutions Inc.

Outline

- Purpose of pavement design
- Pavement evaluation
- Pavement design procedures
- Material characteristics
- Structural coefficients / GE values
- 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

- Coring
  - Needed for mix design
  - Delaminated / stripped layers
  - Dynamic cone penetrometer option
- More important for CIR & FDR:
  - 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 (exceptions – raveling, cohesion) and HIR
- Bituminous CIR and FDR can have slightly lower modulus than HMA
  - Cement FDR acts like a weak PCC
  - Mechanical FDR acts like granular base
- HIR acts like HMA

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
- HIR
  - < 1% recycling agent

Pavement design procedures

- 1993 AASHTO Guide for the Design of Pavement Structures
  - Rehab design: $SN_{OL} = SN_f – SN_{eff}$
- Caltrans Flexible Pavement Rehabilitation Manual
- Mechanistic Empirical Pavement Design Guide
  - NCHRP study underway for CIR and FDR

Pavement design – surface courses

- 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

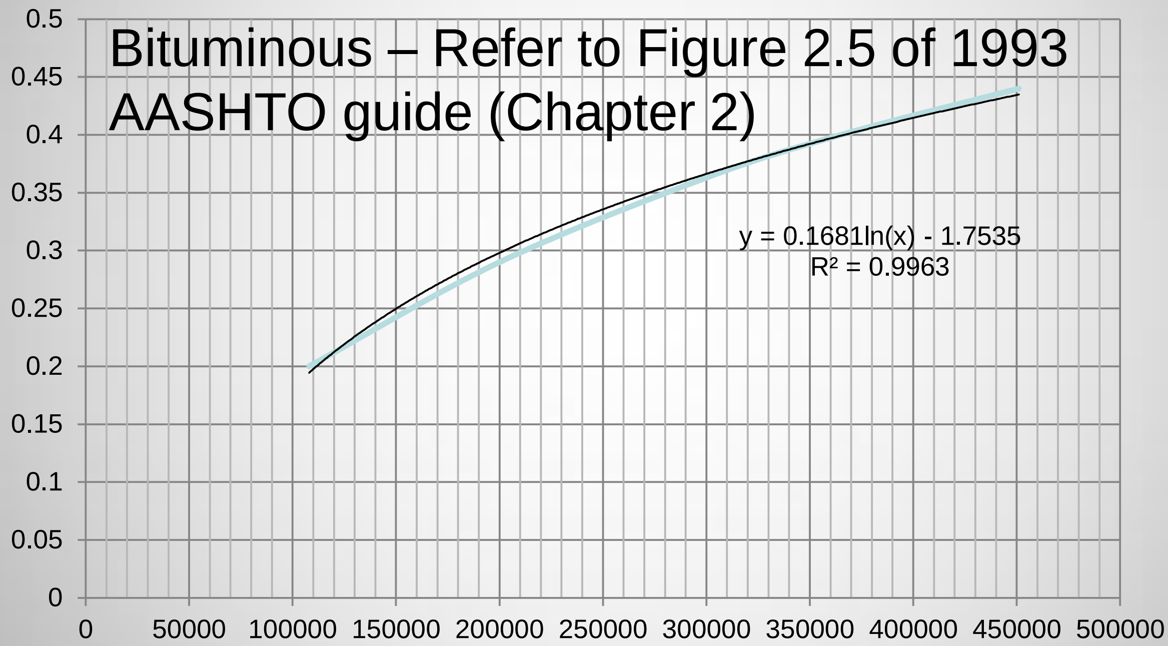
The recycled layer must be covered by at least a bituminous treatment (i.e. micro surfacing or chip seal). The specific treatment needed will depend on pavement design and ride expectations.

Structural coefficients / granular factors

Treatment (and thickness)	AASHTO coefficient range	Caltrans G_f
HMA / HIR (3/4" to 2.5")	0.40 – 0.44	1.9
Aggregate base (6-14+")	0.10 – 0.12	1.1
Mechanical FDR (6-10")	0.10 – 0.12	
Bituminous FDR (4-8")	0.20 – 0.28 (0.25)	(1.4 – 1.6)
Chemical FDR (8-10")	0.14 – 0.23	1.2 – 1.6 (PC)
CIR (2-5")	0.28 – 0.33 (0.30)	1.5 – 1.7

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

Structural coefficients / granular factors



Determined from resilient modulus testing of cores, lab-prepared specimens, or in-place deflection measurements (preferred)

Pavement design

- The pavement structure – depth of recycling and overlay thickness – is primarily influenced by:
  - Traffic – especially trucks
  - Subgrade type and properties
  - Aggregate base or stabilized base thickness, type, and quality / condition
  - Deflection measurements
  - Additive properties used in recycling
  - Climate
  - Design life

Example as-built structures

- 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
- HIR
  - Preservation product
  - Leaves a portion of existing asphalt pavement in place

CIR examples

- 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
- 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

CIR 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 examples

- 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
- Fairburn, Georgia
  - 4260 AADT, two lanes
  - Before: 4” HMA over 7” aggregate base
  - After: Widened road. 3.25” HMA over 6” FDR

FDR 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

HIR examples

- Milwaukee, WI (68th Street)
  - Four lanes, city street traffic (residential)
  - Before: 3” HMA over concrete
  - After: 2” HIR (final surface) over remaining HMA

Before

After

HIR examples

- Oklahoma Turnpike (Turner)
  - 28,000 AADT and 20% trucks
  - After: ¾” new UTBWC over 2” HIR over full depth asphalt

Summary and Conclusions

- Evaluate the pavement carefully for design inputs
- Ensure proper project selection for treatment
- Evaluate different pavement design alternatives and finalize choice
- Perform a mix design with a reliable method
- Verify structural coefficient or granular factor if new to the process

Resources

Valuable resources if more information is needed…

- 1993 AASHTO Guide for Design of Pavement Structures
- Caltrans Flexible Pavement Rehabilitation Manual
- 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!

Todd Thomas, P.E.
Colas Solutions, Inc.
7374 Main Street
Cincinnati, Ohio 45244
Direct: 513-272-5657
Email: tthomas@colassolutions.com
www.colassolutions.com