Field Translations of Laboratory Tests for Cold In-Place Recycling (CIR) and Full Depth Reclamation (FDR)

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Brief History of Recycling

- Pavement recycling processes have been in practice for more than 30 years.
  - Original practices often relied on available materials, equipment and judgment calls alone to build pavements.
  - Resulting roads yielded inconsistent performance characteristics and lacked reliability.

Re-examining Recycling

- An attempt was made to resurrect the recycling processes by first evaluating the undesirable results.
- Based on the observed mechanisms of failure, test methods were identified to predict and prevent them from occurring.

Re-examination Results

- Extended user delays
- Surface raveling
- Inconsistent dispersion
- Thermal cracking
- Poor strength under traffic
- Moisture resistance
- No basis for optimization
- No widespread consistency for mix design

Recycling Gets New Life

- Test methods were identified to serve as indicators of performance for recycled pavements.
- A new generation of recycling was born which combined considerations for existing materials, available resources, newer technology and observed failures to yield performance based test methods.

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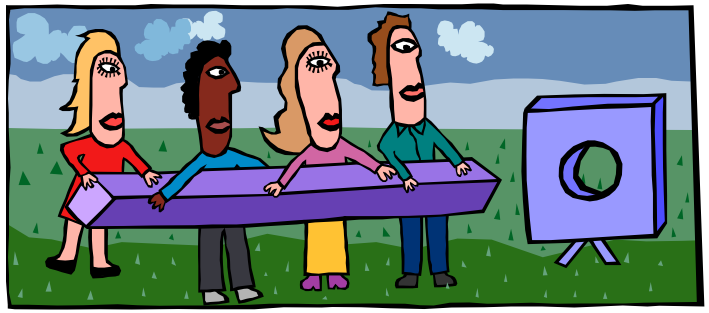
Selecting Test Methods

- Initial ideas had us looking to HMA for test methods
- Subsequently, we looked at testing protocols from soil applications
- Further considerations led us to the conclusion that recycled pavements required categories and test methods of their own.



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Categories of Lab and Field Testing to be Discussed

- Cold In-Place Recycling
  - Emulsified Asphalt
  - Expanded / Foamed Asphalt
- Full Depth Reclamation (FDR)
  - Emulsified Asphalt
  - Expanded / Foamed Asphalt

Cold In-Place Recycling (CIR)

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Cold In-Place Recycling (CIR)

- CIR is the on-site recycling process to a typical treatment depth of 2 to 5 inches using a train of equipment (tankers, milling machine, crushing and screening units, mixers, a paver, and rollers), an additive or a combination of additives (i.e. asphalt emulsion), generating and re-using 100% RAP *(partial depth),* with the resulting recycled pavement usually opened to traffic at the end of the work day (ARRA).

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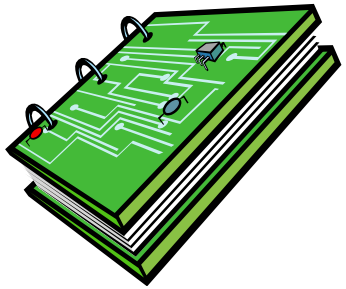
CIR Performance Laboratory Test Methods – Emulsified Asphalt

- Considerations for Emulsified Asphalt
  - Mix Design, (Basic Asphalt Recycling Manual)
  - Marshall Stability, ASTM D 1559
  - Retained Stability
  - Indirect Tensile Test, AASHTO T322
  - Raveling Test, ASTM D 7196



CIR Performance Field Test Methods – Emulsified Asphalt

- Considerations for Emulsified Asphalt
  - Temperature of Emulsion
  - Weather
    - Ambient temperature should always be recorded and considered as it may affect mixture performance
  - Maximum Aggregate Size
    - Should be 100% passing 1 ½" sieve
    - To be evaluated multiple times throughout the day
    - Affects the ride and appearance of the recycled pavement
  - Gradations
    - May be run twice per day (suggested)
    - Utilizing standard sieve stack from 1 ½" to #30
    - Affects the amount of emulsion required to obtain performance results comparable to the lab mix design

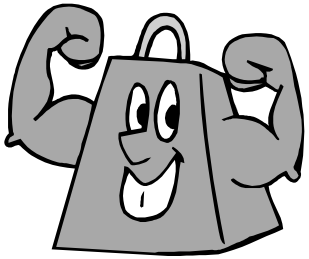
CIR Performance Field Test Methods – Emulsified Asphalt

- Growth Curve
  - Performed at the beginning of the first day
  - Used to determine rolling pattern AND target maximum density
  - Should be repeated when there is a known change in in-situ materials or significant increase in emulsion content.

- Addition rate of recycling agent (yield check)
  - Should be completed on the first day and periodically thereafter
  - Can ensure that the appropriate amount of emulsion is being added
  - Can be completed using an entire tanker or designated length (i.e. 1,000 ft) and a calibrated meter
- Density determination
  - Measured using a nuclear moisture density gauge
  - Field measurements should be based in wet density values alone
  - Provides and immediate indicator of compaction and quality
  - Successful placement should yield test results a minimum of 95% (likely 98% of the target density as determined by the growth curve)

CIR Performance Laboratory Test Methods – Foamed Asphalt

- Considerations for Emulsified/Foamed Asphalt
  - Mix Design (Wirtgen Cold Recycling Manual)
  - Gradation
  - Asphalt Foaming Characteristics
  - Filler Application Rate
  - Modified Proctor – ASTM D1557
  - Indirect Tensile Strength (ITS) – ASTM D4867
  - Retained ITS
  - Indirect Tensile Test – AASHTO T322



CIR Performance Field Test Methods – Foamed Asphalt

- Temperature of Asphalt
  - Asphalt should not be accepted below the minimum temperature as indicated by the mix design
  - Cooler material will not have the same expansion characteristics as the mix design and can affect performance
- Weather
  - Ambient temperature should always be recorded and considered as it may affect mixture performance
- Foaming Characteristics
  - Using the test valve on the recycling equipment, it should be determined that the material is indeed foaming
  - Should be checked at the beginning of each tanker load
- Filler / Cement application rate
  - Using a tarp or canvas of designated size and a balance, it should be determined that the correct amount of dry filler is being added prior to the introduction of the recycler

CIR Performance Field Test Methods – Foamed Asphalt

- Maximum Aggregate Size
  - Should be 100% passing 1 ½" sieve
  - To be evaluated multiple times throughout the day
  - Affects the ride and appearance of the recycled pavement
- Growth Curve
  - Performed at the beginning of the first day
  - Used to determine rolling pattern AND target maximum density
  - Should be repeated when there is a known change in in-situ materials or significant increase in emulsion content.
- Addition rate of recycling agent (yield check)
  - Should be completed on the first day and periodically thereafter
  - Can ensure that the appropriate amount of emulsion is being added
  - Can be completed using an entire tanker or designated length (i.e. 1,000 ft) and a calibrated meter

CIR Performance Field Test Methods – Foamed Asphalt

- Density determination
  - Measured using a nuclear moisture density gauge
  - Field measurements should be based in wet density values alone
  - Provides and immediate indicator of compaction and quality
  - Successful placement should yield test results a minimum of 95% (likely 98% of the target density as determined by the growth curve)
- Maximum Target Density determination (Alternate)
  - An alternate option for determining the maximum target density for Foamed Asphalt is to compact a single point using the Modified proctor, ASTM D 1557, Method C (this procedure should be completed in the field)
  - The resulting wet density as determined in the field should effectively serve as the peak value
  - Successful placement should yield test results a minimum of 95% (likely 98% of the target density as determined by the growth curve)

CIR Performance Field Test Methods – All

- Lab Testing of Field Samples
  - Wet samples, from both methods of CIR may be obtained from the field and transported to a laboratory for additional testing
  - Materials should be placed in sealed containers and transported to a laboratory within 2-4 hours of sampling to obtain the most comparable results
- Additional Testing
  - Tests such as Resilient Modulus and IDT may be completed on lab compacted field samples at a later time
  - Upon completion of recycling, processes such as Falling Weight Deflectometer (FWD) and Ground Penetrating Radar (GPR) may be used to further assess quality

Full Depth Reclamation (FDR)

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Full Depth Reclamation (FDR)

- Full Depth Reclamation* (FDR) Rehabilitation technique where full thickness of asphalt pavement & predetermined portion of underlying materials are uniformly pulverized & blended to an upgraded, homogenous base material

Full Depth Reclamation (FDR)

- Types of FDR
  - **Mechanical stabilization** – FDR without addition of binder (Pulverization)
  - **Chemical stabilization** – FDR with chemical additive (Calcium or Magnesium Chloride, Lime, Fly Ash, Kiln Dust, Portland Cement, etc.)
  - **Bituminous stabilization** – FDR with asphalt emulsion, emulsified recycling agent, or foamed / expanded asphalt additive
  - **Combination stabilization** – Any 2 or more of above

FDR Performance Laboratory Test Methods – Emulsified Asphalt

- Lab Tests for FDR with Emulsified Asphalt
  - Mix Design
  - Gradation / Passing #200
  - Modified Proctor – ASTM D1557
  - Sand Equivalency – ASTM D2419
  - Short Term Strength – ASTM D1560
  - Indirect Tensile Strength (ITS) – ASTM D4867
  - Retained ITS
  - Resilient Modulus – ASTM D4123
  - Indirect Tensile Test – AASHTO T322

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FDR Performance Field Test Methods – Emulsified Asphalt

- Considerations for Emulsified Asphalt
  - Temperature of Emulsion
  - Weather
    - Ambient temperature should always be recorded and considered as it may affect mixture performance
  - Moisture
    - Moisture content should be checked prior to the addition of the emulsion
    - The moisture content should be within 1% of the optimum water content as specific by the mix design
  - Maximum Aggregate Size
    - Should be 100% passing 2” sieve
    - To be evaluated multiple times throughout the day
    - Affects the ride and appearance of the recycled pavement

FDR Performance Field Test Methods – Emulsified Asphalt

- Addition rate of recycling agent (yield check)
  - Should be completed on the first day and periodically thereafter
  - Can ensure that the appropriate amount of emulsion is being added
  - Can be completed using an entire tanker or designated length (i.e. 1,000 ft) and a calibrated meter
- Visual checks for compaction
  - Breakdown rolling/compaction is completed by a padfoot roller
  - In order to ensure adequate compaction, the padfoot should walk out of the material while rolling, meaning daylight should be visible under the drum
- Maximum Target Density determination
  - In order to determine the maximum target density for FDR, a single point is compacted using the Modified proctor, ASTM D 1557, Method C (this procedure should be completed in the field)
  - The resulting wet density as determined in the field should effectively serve as the peak value
  - Successful placement should yield test results a minimum of 95% (likely 98% of the target density as determined by the growth curve)
- Density determination
  - Measured using a nuclear moisture density gauge in direct transmission mode
  - Field measurements should be based in wet density values alone
  - Provides and immediate indicator of compaction and quality
  - Successful placement should yield test results a minimum of 95% (likely 98% of the target density as determined by the growth curve)

FDR Performance Laboratory Test Methods – Foamed Asphalt

- Considerations for Emulsified/Foamed Asphalt
  - Mix Design (Wirtgen Cold Recycling Manual)
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  - Resilient Modulus

FDR Performance Field Test Methods – Foamed Asphalt

- Considerations for Foamed Asphalt
- Temperature of Asphalt
  - Asphalt should not be accepted below the minimum temperature as indicated by the mix design
  - Cooler material will not have the same expansion characteristics as the mix design and can affect performance
- Weather
  - Ambient temperature should always be recorded and considered as it may affect mixture performance
- Moisture
  - Prior to the addition of the foamed asphalt, the moisture content should be checked
  - Should be within 2% of the optimum moisture content as determined in the lab mix design
- Foaming Characteristics
  - Using the test valve on the recycling equipment, it should be determined that the material is indeed foaming
  - Should be checked at the beginning of each tanker load

CIR Performance Field Test Methods – Foamed Asphalt

- Filler / Cement application rate
  - Using a tarp or canvas of designated size and a balance, it should be determined that the correct amount of dry filler is being added prior to the introduction of the reclaimer
  - In slurry applications, the rate should be predetermined
- Maximum Aggregate Size
  - Should be 100% passing 1 ½" sieve
  - To be evaluated multiple times throughout the day
  - Affects the ride and appearance of the recycled pavement
- Addition rate of recycling agent (yield check)
  - Should be completed on the first day and periodically thereafter
  - Can ensure that the appropriate amount of emulsion is being added
  - Can be completed using an entire tanker or designated length (i.e. 1,000 ft) and a calibrated meter
- Visual Checks for compaction
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FDR Performance Field Test Methods – All

- Lab Testing of Field Samples
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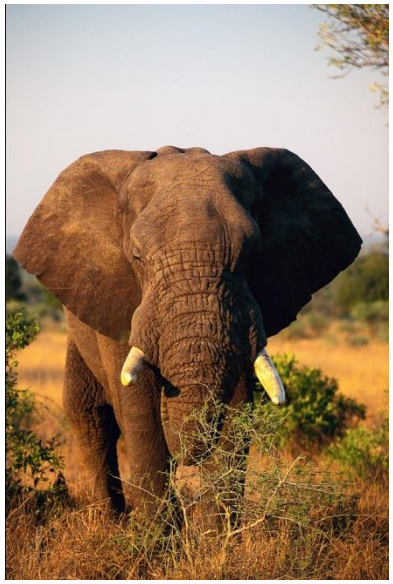
  - Materials should be placed in sealed containers and transported to a laboratory within 2-4 hours of sampling to obtain the most comparable results
- Additional Testing
  - Tests such as Resilient Modulus and IDT may be completed on lab compacted field samples at a later time
  - Upon completion of recycling, processes utilizing the Dynamic Cone Penetrometer (DCP), Falling Weight Deflectometer (FWD) and Ground Penetrating Radar (GPR) may be used to further assess quality

FDR and CIR Lab and Field Testing – Final Considerations

- Field testing is a means of ensuring the performance of the recycled material by using the field renderings to duplicate what has been observed during the mix design process
- Performance criteria for the recycled product should be determined in the specification phase and during the design process
- With a proper field investigations, sampling, mix design and quality testing, successful recycled pavements can be built with predictable and repeatable performance

Questions?



Thank you!

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