DEVELOPMENT OF MIX DESIGN AND STRUCTURAL DESIGN PROCEDURES FOR COLD IN-PLACE RECYCLING

Pavement Engineering and Science Program
University of Nevada, Reno

Progress – Update
October 26, 2016
# Experimental Program

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<th>Emulsion</th>
<th>Slurry Level</th>
<th>Mix Design</th>
<th>M-E Design</th>
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4.5 = 1.5%HL + 3%W  
6.0 = 2%HL + 4%W  

E* = Dynamic Modulus  
RC = Reflective Cracking  
Fn = Flow Number  
FC = Fatigue Cracking  

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Superpave Mix Design

- Air voids: 13±1%
- Identify $N_{\text{design}}$
- Identify OEC
- Check:
  - Moisture Sensitivity
  - Raveling
  - Cohesion
RAP Gradation

Graded RAP:
- PCCAS medium gradation

Non-Graded RAP:
- 100% passing 1.5” (NDOT)
Samples Fabrications

- RAP material: whole barrel
- Crush RAP: aggregate crusher
- Shovel mix the RAP, ensuring uniform distribution

- Oven dry RAP at 140°F, until constant mass (24-48 hours)
- Graded mixture
  - Sieve according to PCCAS
- Non-Graded mixture
  - Quarter using Splitter
  - Batch
  - Batch
Identify \( N_{\text{design}} \)

- Emulsion content: 3.0%
- Compact to 100 gyrations
- Measure Theoretical Maximum (\( G_{\text{mm}} \)) & Bulk Specific (\( G_{\text{mb}} \)) Gravities
- Identify the number of gyrations:
  - Height: 115±5mm
  - Air voids (%AV): 13±1%
Number of SGC Gyrations

Graded RAP - Emulsion type B - 6.0% Slurry Lime

Average Height: 115.0 mm
Average Air voids: 12.6%

70 Gyrations
Number of SGC Gyrations

Non-Graded RAP - Emulsion type B - 6.0% Slurry Lime

Average Height: 117.3 mm
Average Air voids: 13.5%

100 Gyrations

Sample 1  Sample 2  Sample 3
Identify Optimum Emulsion Content

- Mix samples at: 2.5, 3.0, 3.5, and 4.5% emulsion

- Lime slurry: 4.5% and 6.0%

- Measure $G_{mm}$ at 3.0% and calculate at others

- Compact to $N_{\text{design}}$ and measure $G_{mb}$

- Identify OEC:
  - %AV and Height
Effective Specific Gravity

Average $G_{se}$
Optimum Emulsion Content (OEC)

Graded RAP - Emulsion type B - 6.0% Slurry Lime – 70 Gyrations

*y* = 0.008x^2 - 0.0691x + 0.267

R² = 0.8943

3.1% OEC
Non-Graded RAP - Emulsion type B - 6.0% Slurry Lime – 100 Gyrations

Optimum Emulsion Content (OEC)

Air Voids vs. Emulsion Content

Height vs. Emulsion Content

\[ y = 0.0029x^2 - 0.0311x + 0.1975 \]

\[ R^2 = 0.8981 \]

3.0% OEC
Samples Acceptance Criteria

• Additional Samples are Compacted if:
  – Repeatability of the $G_{mb}$ does not meet:
    ▪ Standard Deviation $d_{2s}$
    ▪ Maximum Difference
  – The Fit of the data is unacceptable
    ▪ $R^2 < 0.75$
## Superpave Mix Designs

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<th>Emulsion</th>
<th>Lime (%)</th>
<th>Aggregate</th>
<th>Air Voids (%)</th>
<th>OEC(%)</th>
<th>$R^2$</th>
<th>No. of Gyration</th>
<th>No. of Samples</th>
<th>Cohesion (hrs)</th>
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Some Trends

- All Non Graded Mixtures Required $N = 100$

- Graded Mixtures $N = 70 - 85$ (D: 60-65)

- Number of Required Samples Higher for Non Graded Mixtures

- Optimum Emulsion Content Higher for Non Graded
Next Task: Hveem Mix Design

- Air Voids: 13±1%
- Identify Leveling Load
- Identify OEC
- Check:
  - Moisture Sensitivity
  - Raveling
  - Cohesion
Identify Number of Tamps

- Emulsion content: 3.0%
- Compact to 150 tamps
- Measure $G_{mm}$ and $G_{mb}$
- Identify the leveling load:
  - Height: 2.5±0.1 inch
  - Air voids (%AV): 13±1%
Identify Optimum Emulsion Content

- Mix samples at: 2.5, 3.0, 3.5, and 4.5% emulsion
- Lime slurry: 4.5% and 6.0%
- Measure $G_{mm}$ at 3.0% and calculate at others
- Compact and apply leveling load: measure $G_{mb}$
- Identify OEC:
  - %AV and Height
# Hveem Mix Designs

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<th>Emulsion</th>
<th>Slurry Lime (%)</th>
<th>Aggregate</th>
<th>Air Voids (%)</th>
<th>OEC(%)</th>
<th>R²</th>
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Thank You!