Overview

- Current Guidelines
- High RAP Content Mix Design Issues
  1. Characterizing RAP
  2. Laboratory Sample Preparation
  3. Selecting the Virgin Binder
  4. Performance Tests
Mix Design with High RAP Contents

- Current mix design approach is reasonably sound
- Additional guidance needed on:
  - Characterizing RAP
  - Preparing samples in the lab
  - Determining the appropriate PG for the virgin binder
  - Recommendations for performance testing
- Previous studies indicate that the biggest risk is long-term durability (resistance to cracking)
Current Superpave Guidelines for RAP

- Tier 1: Up to 15% RAP *Binder*
  - use specified binder grade
- Tier 2: 15%-25% RAP *Binder*
  - use one full binder grade lower, e.g., PG 58-28 instead of PG 64-22
- Tier 3: Over 25% RAP *Binder*
  - use blending charts to determine required binder grade
RAP Nomograph - High PG Temp.
Binder Characterization Issues

- Can we determine RAP binder properties without solvents?
- Is traditional blending approach correct?
  - Is there 100% blending?
  - Should we adjust the virgin binder grade at all?
Testing RAP

- Asphalt Content:
  - ignition method is preferred.
  - An aggregate correction factor must be assumed.
  - For regions that utilize dolomite aggregates that have erratic correction factors, a solvent extraction method is recommended.
Testing RAP

Aggregate bulk specific gravity: estimated from a three step process

1. Determine Gmm of RAP sample
   - Add 1% binder to recoat aggregate and avoid dryback
2. Calculate Gse using the Gmm from step 1 and the asphalt content from the ignition method (or extraction test if ignition method is not reliable)
3. Estimate Gsb from Gse using a typical offset value or regression from historical mix designs with the aggregates in the region
Why Use This Process?

When the RAP asphalt content and binder absorption can be estimated with confidence, this process is more accurate and faster than recovering the aggregate from solvent extraction or ignition test and performing T84 and T85
Effect of RAP Agg. Gsb on VMA

Gsb Virgin = 2.6700
Testing RAP

- Other key RAP aggregate properties can be performed on aggregate recovered from the ignition oven or solvent extractions.
  - Gradations
  - Fine aggregate angularity
  - F&E
  - Fractured faces
At least 10 samples when building stockpile

Split each sample

Ignition method tests

Max. specific gravities

gradations

asphalt contents

Combine samples for other aggregate tests

Gse → Gsb

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Handling the RAP for Mix Design

- Drying RAP
  - RAP needs to be dried before testing and batching
  - Dry RAP spread in thin layer with fans overnight, followed by placement in an oven at 230F for one hour max.
Handling the RAP for Mix Design

- Batching
  - Develop trial blends using gradation of aggregate recovered from RAP
  - Screen the RAP down to the 4.75 mm sieve as with coarse aggregate stockpiles
  - Batch using dried RAP
Handling the RAP for Mix Design

- Heating the RAP
  - Heat batched RAP in covered cans separate from virgin aggregate for the minimum amount of time to reach the mixing temperature
  - This time will typically range from 2 to 4 hours depending on the mass of the batches and the oven efficiency
# Preliminary RAP Heating Results

*Theoretical Asphalt Content = 2.44%*

*RAP binder True Grade: 85.1-15.7*

<table>
<thead>
<tr>
<th>Virgin Heating Time</th>
<th>Virgin Temp.</th>
<th>RAP Heating Time</th>
<th>RAP Temp.</th>
<th>Average Asphalt Content</th>
<th>Recov. PG</th>
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Mix Design for High RAP Contents

- Start mix design with standard virgin binder grade
- Determine optimum binder content in accordance with M 323
- Estimate the “effective binder grade” in the mixture using an indirect approach
- If the effective binder grade is suitable, then perform appropriate performance tests
- If the effective binder grade is too stiff, select a new virgin PG and repeat step 3
Backcalculation of Effective Binder Grade

- Prepare and test specimens for dynamic modulus, AASHTO TP 63
- Test at 3 temperatures, 7 frequencies
- Calculate G* from Hirsh model, δ using G. Rowe’s technique
Proposed Performance Test Options

- Moisture Susceptibility (always)
  - TSR or Hamburg
- Permanent Deformation (mixes within top 100 mm)
  - AMPT Flow Number or APA
- Fatigue (surface or base mixes)
  - AMPT fatigue or Overlay Tester
- Low Temperature (for cold climates)
  - SCB and BBR with mix beams
Summary

- Sample and Test RAP
- Conduct mix design as usual
- Use dynamic modulus test (with AMPT) to check the effective binder grade, adjust virgin PG as needed
- Conduct performance tests as appropriate and check against criteria for standard mixes
- Majority of the process is conducted by routine mix design labs
- Additional testing will add roughly one week