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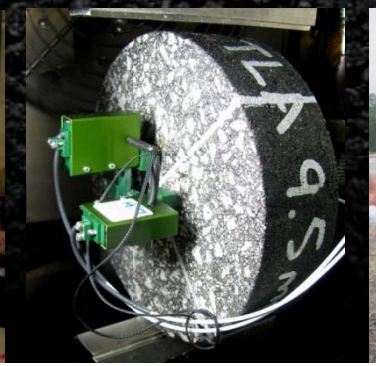
NCHRP 9-46
High RAP Content Mix Design

RAP ETG Mtg. OKC, October 26, 2010


Overview

- Status of Project
- Research Approach
- Preliminary Recommendations

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9-46 Project Status

- Research team: NCAT, UMN, UNH
- Original schedule: draft final report 9/10
- Issues casing delays
  - Fatigue testing
  - Back-calculation difficulties
  - Loss of key staff
  - Confined Dynamic Modulus pressure

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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)

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Experiment

- Mix Designs with 4 sets of materials: UT, MN, NH, FL
- RAP Contents: 0 & 40% or 0, 25, & 55%
- Two binder grades and two binder sources
- Volumetrics, E*, FN, TSR, SCB and BBR, and Push-Pull fatigue
  - Volumetric results – some are questionable
  - E* - about half to be retested because they were not properly vented
  - FN - no apparent tertiary flow, evaluating total strain
  - TSRs – some up, some down

Characterizing 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.

Characterizing RAP

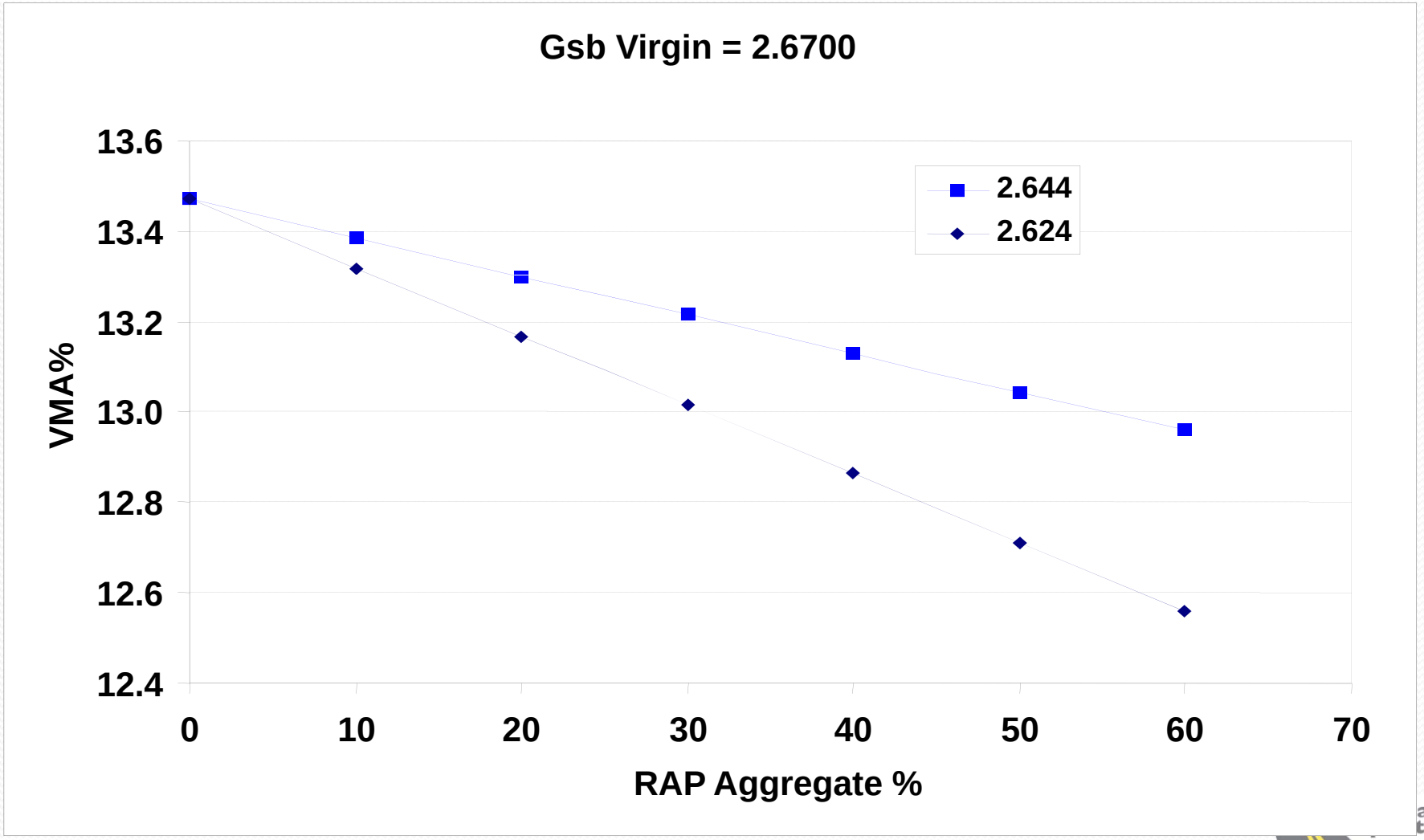
Aggregate bulk specific gravity: estimated from a three step process

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



Characterizing 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

RAP Sampling & Testing Flowchart

At least 10 samples when building stockpile

Split each sample

Ignition method tests

Max. specific gravities

gradations

asphalt contents

Gse → Gsb

Combine samples for other aggregate tests

Pete Capon Rieth-Riley RAP Summaries [Compatibility Mode] - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Acrobat

B4 Sieve Size- Per Cent Passing

	A	B	C	D	E	F	G	H	I
4		Sieve Size- Per Cent Passing							
5	**Test #**	**1.0"**	**3/4"**	**1/2"**	**3/8"**	**#4**	**#8**	**#16**	**#30**
6	1	100.0	100.0	95.0	84.5	58.1	44.8	32.7	24.6
7	2	100.0	98.9	96.7	91.1	71.2	53.8	43.9	35.2
8	3	100.0	100.0	96.4	90.2	66.8	49.9	36.2	25.9
9	4	100.0	100.0	95.5	89.0	66.4	50.0	39.1	30.1
10	5	100.0	100.0	96.6	89.8	67.1	49.2	35.9	26.8
11	6	100.0	100.0	95.5	88.9	62.0	45.6	34.4	26.5

Summary & Analysis of RAP Data

- Calculate average and standard deviation of asphalt contents, gradations, and estimated Gsb
- Compare to the recommended tolerances

RAP property	Max. Standard Deviation (%)
Asphalt Content	**0.5**
% Passing Median Sieve	**5.0**
% Passing 75 micron Sieve	**1.0**

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 the mix 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 samples

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

Virgin Heating Time	Virgin Temp.	RAP Heating Time	RAP Temp.	Average Asphalt Content	Recov. PG
3 hours	355 °F	30 min	355 °F	1.98	85.0-17.8
3 hours	355 °F	3 hours	355 °F	2.11	89.3-13.9
16 hours	355 °F	16 hours	355 °F	0.79	n.a.
3 min	500 °F	0	Room Temp.	2.35	95.0-10.0

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 technigue

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 and may initially require farming out to specialist labs

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Thank You

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