USE OF RECLAIMED ASPHALT PAVEMENT IN UNBOUND BASE AGGREGATE LAYER

Saad Ullah (PhD Student) – George Mason University (GMU)
Burak F. Tanyu (Asst. Professor) – George Mason University (GMU)
Edward Hoppe (Associate Principal Research Scientist) – Virginia Dept. of Transportation (VDOT)
Michael Brown (Associate Director) – Virginia Department of Transportation (VDOT)
INTRODUCTION

• Recycling Asphalt Roads
  – Binder production (Asphalt Recovery)
  – Unbound Base Aggregate
• What is RAP? How it is produced?
  – Reclaimed Asphalt Pavement (RAP): Reclaimed material is produced during milling operation of pavements.

• Why do we want to recycle RAP?
  – According to recent VCTIR study (2015), there is approximately 4.7 million tons of excess RAP stockpiled in VA.
  – US highway construction industry annually produces 100 million tons of RAP. (NAPA 2009)

• Advantages:
  – Up to 30% in material cost savings if approximately 50% RAP is allowed for use as unbound base material. (VCTIR 2015)
LOCATIONS OF RAP STOCKPILES

One half of total is located in Northern Virginia

Source: VCTIR 2015
MATERIAL COST SAVING

Source: VCTIR 2015
USE OF RECLAIMED ASPHALT PAVEMENT IN UNBOUND BASE AGGREGATE LAYER

Waste Asphalt Mixtures

Processed Asphalt Mixtures

Degraded Pavement Layer

Use of RAP as Base Aggregate and Surface HMA
Mechanistic Empirical Pavement Design Guide (MEPDG)

Climate

Level 1: I know a lot about this input…
Level 2: I know some about this input…
Level 3: I know very little about this input…

Materials

Response

Damage Accumulation

Time

Damage

Traffic

Structure

Distress
Background of Study

• Taha Ramzi (1999)
  – RAP/ Clean Aggregate blends:
    • 0/100, 20/80, 40/60, 60/40, 80/20, 100/0.
  – CBR (California bearing ratio) decreased with increased RAP percentage.
  – Max dry density decreased with increased RAP percentage.
    • As a consequence of that void ratio decreases and permeability increases (That’s our conclusion)
Background of Study

• Bennert et al. (2000)
  – RAP/ Clean Aggregate blends:
    • 0/100, 25/75, 50/50, 75/25, 100/0.
  – **Resilient Modulus** increased with the increase in RAP percentage.
  – **Shear strength** decreased with the increase in RAP percentage.
  – **Permanent deformation** increased with increasing RAP percentage.
  – **Conclusion**: RAP is stiffer than aggregates but accumulates higher strain.
Background of Study

• Kim et al. 2002
  – RAP/ Clean Aggregate blends:
    • 0/100, 25/75, 50/50, 75/25.
  – **Resilient Modulus** increased with the increase in RAP percentage.
  – **Permanent deformation** increased with increasing RAP percentage.

• McGarrah (2007)
  – Shear strength decreased with increase in RAP percentage.
Background of Study

• Wu et al. 2012
  – Studied influence of RAP content on void ratio, permeability and modulus of RAP/ virgin aggregate blends.
  – RAP/ Clean Aggregate blends:
    • 0/100, 20/80, 40/60, 80/20.
  – Permeability: Draining capability decreased with increased RAP percentage. (Porosity decreased)
  – X-ray CT-Scan results confirmed it.
## Inconsistencies

<table>
<thead>
<tr>
<th>Reference</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramzi et al. (1999)</td>
<td>Concluded that moisture holding capability of RAP is negligible (Higher permeability)</td>
</tr>
<tr>
<td>Bennert et al. (2000)</td>
<td>Concluded that max. dry density decreased with increase in RAP content.</td>
</tr>
<tr>
<td>Kim et al. (2007)</td>
<td>Increase in permeability with increase in RAP content.</td>
</tr>
<tr>
<td>Wu et al. (2012)</td>
<td>Concluded that there is decrease of permeability with the increase in RAP percentage.</td>
</tr>
<tr>
<td></td>
<td>X-ray CT scan results predicted decrease in void ratio.</td>
</tr>
</tbody>
</table>
Main Objective

• Develop additional means to enable greater use of RAP in Virginia to expedite the depletion of existing 4.7 million tons of excess RAP stockpiled and to minimize the continued addition to this stockpile over the years.
Proposed Research Objectives

• **Objective 1** – Develop a performance-based equivalency

• **Objective 2** – Evaluate the in-situ long-term performance of the RAP/aggregate mixtures to develop guidelines for implementation
Laboratory Program

Locations for sample collections and evaluation of any available information about stockpiled RAP such as GSD, binder content, and available tonnage. Properties of the samples collected from each stockpile will be tested in the laboratory to evaluate the variability within each stockpile in the field. RAP/ Clean Aggregate mixtures: (10/90, 20/80, 40/60, 50/50 and 60/40). Permanent deformation, resilient modulus, and CBR tests.
Locations visited

- Loc. 1: Manassas 1
- Loc. 2: Gainesville
- Loc. 3: Manassas 2
- Loc. 4: Warrenton
- Loc. 5: Chantilly
- Loc. 6: Herndon
- Loc. 7: Bealton
- Loc. 8: Ashburn
- Loc. 9: Alexandria
- Loc. 10: Stafford
Locations visited

Loc. 11: Fredericksburg
Loc. 12: Southern Virginia
Loc. 13: Mitchells
Loc. 14: Southern Virginia 1
Loc. 14: Southern Virginia 2
Fine processed RAP Stockpile

Unprocessed RAP Stockpile
• Types of RAP Samples

- **Processed Fine RAP:**
  Crushed RAP passing 12.5 mm

- **Processed Coarse RAP:**
  Crushed RAP between 19-12.5mm

- **Unprocessed RAP:**
  Material obtained as a result of milling.
SELECTION OF HMA PLANT LOCATION FOR RESEARCH PROGRAM

• As per proposed research plan we have selected highest and lowest binder content RAP available in Virginia.

• GMU selected samples:
  – (BrM) = 5.44 – 5.86  Highest in Virginia
  – (BC) = 4.53 – 4.73  Lowest in Virginia

• Target Blends for both scenarios:
  – 20RAP-80VA, 30RAP-70VA, 40RAP-60VA, 50RAP-50VA and 60RAP-40VA
Performance Evaluation

- Permanent deformation test
Potential Benefits

– 5 million tons of RAP stockpiles have been identified in VA.

– Being able to have the opportunity to use RAP as base aggregate promotes sustainable development to reduce RAP stockpiles and still supports the aggregate industry.

– This study is needed to develop specifications. It will most likely also be used to justify use of greater percentage RAP content.
THANK YOU...

Questions?
BACKUP SLIDES
Truck feeding Raw material

Screening of material

> 25.4 mm
19.0 mm
12.5 mm

Processed Coarse RAP

Processed Fine RAP

Crusher
21 Aggregate Upper and Lower Limits

Mechanical Sieve Analysis

<table>
<thead>
<tr>
<th>Coarse</th>
<th>Fine</th>
<th>Coarse</th>
<th>Medium</th>
<th>Fine</th>
<th>Silt</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>Sand</td>
<td>Fines</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RAP upper and lower boundaries

- 21 Lower Limit
- 21 Upper Limit
- VAPS
- SPA
GSD of Selected Candidates (Max., Avg. & Min. Binder C.)

Mechanical Sieve Analysis

<table>
<thead>
<tr>
<th>Coarse</th>
<th>Fine</th>
<th>Coarse</th>
<th>Medium</th>
<th>Fine</th>
<th>Silt</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>Sand</td>
<td>Fines</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Particle Size (mm): 3", 2", 1 1/2", 1", 3/4", 1/2", 3/8", #4, #10, #20, #40, #60, #100, #200

Percent Passing (%)

Binder Content
- BrM: 5.40 – 5.92
- CG: 4.60 – 4.70
- BC: 4.53 – 4.73
- SPA: 5.04 – 5.35