Recycling Initiative:
Moving Forward in Road Building, USA Style.

Several hundred million tons of Hot Mix Asphalt (HMA) are made in the USA each year. Agencies buy anywhere from 50 to 90% / year!

Timothy R. Murphy, P.E.
President
Murphy Pavement Technology, Inc.
“Asphalt, more than any other single product, sustains the nation's highway system and facilitates the flow of commerce.”
How to Market Recycling of HMA Successfully

People Working Together to Form

Alliances in Action

Academia - Agency - Association - Consultant - Contractor - Supplier

Build a team to work through the details
Illinois Seminar Locations

- District One (Chicagoland) @ 8 locations
- District Two – Nine @ 8 locations

Consulting firms call for in-house sessions.
Hot Mix Asphalt Plant Tours

- Advanced
- Arrow Road
- Bigane
- Curran
- Gallagher
- Howell
- K-Five
- Peter Baker
- Plote
- Rockford Blacktop
Idaho Seminar Locations

- District One – Two (Coeur d’Alene)
- District Three – Four (Boise)
- District Five – Six (Pocatello)

ITD calls this “outreach”
Social

Economic

Environmental

Bearable

Equitable

Viable

Sustainable
Greenroads is a project-oriented system. It does not deal with planning and it does not deal with operations.
There are a lot of definitions for “sustainable” out there. Most are incomplete. This is what we think “sustainability” means.

**Sustainability** is a system characteristic which refers to the system’s capacity to support natural laws and human values.
We can do better. We can reduce the amount to landfills, and increase the amount to high-value surfacings.

Destination of Recovered HMA
- Landfill 20%
- HMA 27%
- Base Material 53%

Destination of Recovered PCC
- Landfill 20%
- Fill, Rip-Rap and Other 14%
- HMA/PCC 12%
- Base Material 54%

Data from the USGS
A Position to Stand For…

We must be dedicated to safeguarding the environment and transforming the marketplace by promoting the manufacture, purchase, and use of environmentally responsible products and services.
Murphy Position Statement

There is a growth in the use of RAP in the USA, be committed to increasing the use of RAP successfully through proper engineering and production controls.
Position Statement

Volumetric, aggregate, and asphalt characteristics must meet or exceed the current specification requirements and these items will guide the future development and enhancements of your recycling specification.
Research Needs

- Performance test for evaluating RAP
- Best practices manual
- Solvent free method to characterize RAP
- Binder grade changes
- Field performance of high RAP mixes
- Replicating plant heating in lab
MODEL OF DEVELOPMENT OF TECHNOLOGY
- Oujian and Carne, 1987

Research

Implement or Transfer

Development

Engineering

Basic

Applied

Products, Services, Processes, & Policies

Tasks

Technology

Technical Feasibility

Engineering Demonstration

Prototype Field Trial

Basic Applied

Knowledge

Discover Organize Apply
High RAP Mixtures – Who’s Involved?

- Effect on asphalt characteristics and material supply – Asphalt Institute and Liquid Suppliers,
- Coating all particles – increased temps. for drying, heating, and mixing – equipment manufacturers,
- Stripping – visual strip rating – DOT’s Central Office,
- Loss of any performance measure that we deem to be valuable – Agency led Academia,
- Production – APA / AGC HMA Members.
There are 3,000 Hot Mix Asphalt plants in operation today in the USA!
What Jeff Foxworthy might say…

“If you have large RAP stockpiles… You know you’re an redneck urbanite.”

100,000+ tons of ^ at various locations

Photo Dan Gallagher
Storage = Inflow - Outflow

RAP Piles = Milling – Reuse

State Bituminous Engineer
The Captain of our Ship
Asphalt plant quality inputs

Virgin Aggregates

RAP

Slag

Look at the Volumes!!!
30,000 Tons of RAP = 70 - 6,000 Gallon Transport Trailers and 28,200 Tons of Clean Aggregate

from NAPA

RAP is Worth the Virgin Material It Replaces
Recycling Usage = \( f(\text{Quality, Quantity}) \)

Quality = How good it is.
Quantity = How much we have.
Volumetric Analysis such as Voids, VMA, & VFA

Field Density Measurements

Aggregate Gradations (Incoming)

Visual Surface Characteristics

Asphalt Content

Aggregate Gradations (HMA Sample)

HMA Compliance
We have been successful up to now; how will we continue to be successful?

QC / QA
Research
Training
The Essentials to Our Success

1. Create and sustain a breakthrough value proposition. [The Past]
2. Cultivate inner networks. [Today]
3. Customer centric. [The User]
4. Adaptability or finding a better way. [Research]
5. Opportunity focused. [The Specification]
6. Pack your board with industry experts. [The Doers]
7. Use blue-chip customers to gain credibility. [The Future]
Cultivate Inner Networks [Today]

Recycling is increasingly important in the transportation sector. The Federal Highway Administration has a leadership team focused on promoting use of recycled materials, and a number of state transportation agencies have recycling coordinator positions focused on new technologies, research, and getting the word out.
Conferences

- Society of Professional Engineers
- American Public Works Association (APWA)
- Association of Asphalt Pavement Technologists (AAPT)
- National Asphalt Pavement Association (NAPA)
- Numerous State Agencies
Federal Highway Administration Policy Memorandums - Infrastructure Core Business Unit

FHWA Recycled Materials Policy for the National Highway System
Evaluating Products and Posting Results

Nationally, the overall results indicate that the majority of recycled-content products are as good or better than their virgin material counterparts.

- [FHWA / DOT / DOD]
Carper Road in Grundy Co., IL
First 30% RAP surface and binder lifts of HMA placed in Illinois in 1998.
10-Year Old Pavement w/ 30% RAP

‘… I was pleasantly surprised to find it in such good condition.

… we paved the road in 1998. It looks like it could have been paved last year.

… We have many township and County roads which have been paved more recently which are not performing nearly as well.

… it sure appears that this has been the ideal mix for such a road. Thanks for enlightening us on the use of this mix.’

- Craig Cassem, County Engineer; Nov. 2007
The USA Contractor...

...is encouraged to provide reused or recycled materials to the maximum extent possible. Recycled materials currently approved by the Department include glass, recycled asphalt pavement (RAP), recycled portland cement concrete aggregate (RCA), blast furnace slag, fly ash, microsilica, waste stream plastics, and tires.
Growth vs. Recycling over Time

INDUSTRIAL GROWTH

RECYCLING PERCENTAGES

OUR FUTURE

INCREASING VALUES

TIME
We can applaud others' efforts.
Example

Extended Life Pavement Interstates around the nation (total reconstruction)

Can 100% re-use of old pavement occur?
On-site Excavation
Trucking to recycling facility
Crushing & screening feed
Finished product

- Rework stockpile to mitigate segregation and improve consistency.
- Pay special attention to head pulley.
Steel recycling
We’ve come a long way with
The Engineering of RAP
## Potential Savings, 2011

<table>
<thead>
<tr>
<th></th>
<th>Rock ($10/ton)</th>
<th>New Asphalt ($410/ton)</th>
<th>RAP w/5% AC ($6/ton)</th>
<th>Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>94%</td>
<td>$9.40</td>
<td>6% = $24.60</td>
<td></td>
<td>Cost = $34.00</td>
</tr>
<tr>
<td>75%</td>
<td>$7.50</td>
<td>5% = $20.50</td>
<td>20% = $1.20</td>
<td>Cost = $29.20</td>
</tr>
</tbody>
</table>

**Total Savings**

- $2.40 @ 10%
- $4.80 @ 20%

*If placed cost /ton = $50.00, this represents a 10% savings.*
Governor, we need to talk…

What we know:

- 0% RAP costs approximately $5.00/ton more than a 20% RAP mixture.

Somewhere Idaho:

- Place 1-mile by 30 ft. wide, 4" of HMA.

Question: What can you pave?

- Asphalt density = \frac{112 \text{ lb/sq.yd/inch}}{2,000 \text{ lb/ton}}
- Sq. yds. = \frac{5,280 \text{ ft/mile} \times 30 \text{ ft}}{1 \text{ mile}} = 17,600
- Tons = \frac{17,600 \text{ sq.yds.} \times 4"}{9 \text{ sq.ft/sq.yd.}} \times \text{Asphalt density} = 3,942

50-miles @ 4" = $1M
25-miles @ 8" = $1M
16.6 miles @ 12" = $1M
Opportunity is from Agency knowledge on measuring performance with Academia and from Contractor knowledge of their operations.
New Maximum RAP in HMA

- Category 1 & tested Category 2; unlimited.
- Category 2; 10% top lift, 30% all other.

Processed RAP, crushed and screened over 5/8” screen
Proper Signing is Required
Why Process RAP?

- Uniformity
- Consistency
- Quality

Out with the old, In with the new
Raw feed, asphalt

Contractor owns and must manage the material.
Virgin Aggregate Sampling
Unprocessed RAP can be Variable

from Bush, Vulcan Materials Co.
Processed RAP

- Uniform
- Consistent
- QUALITY
- And you can USE MORE, more dependably!

Out with the old, In with the new...
Input to Output

Unprocessed stockpile

Processed stockpile
Two-Stage RAP Crusher Circuit Producing One Product
Portable Crusher

Photo H. Bush, VMC
Contractor Equipment Solution,
Asphalt

Fold ‘n Go
Photo from Astec
Contractor Equipment Solution, Concrete and C&D

Fold ‘n Go
Photo from Astec
High Frequency Screening

If possible, screen RAP first
- Don’t crush if not required
- Generates less fines
- Exposes less aggregate for moisture
High Frequency Screenings with Crushing
Radial Stackers

Photo H. Bush, VMC
Black Gold

[Image of a landscape with hilly terrain, possibly coal deposits, under a green frame]
Crusher and stockpiles of RAP and Concrete
From raw feed to finished product

Raw Feed

Finished Product
-½” RAP Uniform & Consistent

-1/2” Inch RAP

Maximum Density Line

Percent Passing

Sieve Size

#200 #80 #50 #40 #30 #10 #8 #4 3/8” 1/2” 5/8”
In 1990’s we saw fractionating RAP as the future.
Multiple RAP Feeders
Calibrate RAP Belt
In-Line Scalper Before Drum
At the beginning this is what occurred

- Assembled an interdisciplinary project team
- Characterized the waste
- Classified the waste components
- Identified constraints
- Identified end-markets
- Performed economic analysis
- Provided project planning
- Supplied contract administration
- Oversaw project operation.

We must continue...
Pack Your Board with Industry Experts [The Doers]
The Doers Charge

- Retain quality & performance
- Strive for highest value use
- Create policies that have economic sustainability
- Protect the environment
- Identify short and long term issues
  - Specification changes
  - Research topics (Binder, Volumetric’s, LCCA)
The US Approach
[Today, Tomorrow, and The Future]

Active promotion of recycling technology by providing:

1. Needed specifications,
2. Best practices,
3. Design guidance, and
4. Continuing research;

to overcome barriers.
Well Designed Asphalt Mixtures

Construction Methods

Bituminous Hot Mix Production

Bituminous Mix Design

(Starting Point)
Coarse Aggregate Quality

Nothing has changed!
Effective Volume of Asphalt = VMA - \( V_a \)

\[
V_a = \left( \frac{G_{mm} - G_{mb}}{G_{mm}} \right) \times 100
\]

\[
VMA = 100 - \left( \frac{G_{mb} \times P_s}{G_{sb}} \right)
\]

\[
VFA = \left( \frac{VMA - V_a}{VMA} \right) \times 100
\]

Effective Volume of Asphalt = VMA - \( V_a \)
When will we ‘build onto’ the program?

I believe this is just the beginning of increased recycling applications; we are trying to engineer in a changing environment.
When will we ‘build onto’ the program?

You can do it once you have your VMA house in order:

- Aggregate gravity
- Field VMA
- Dust / AC
- AC grading
7. CALCULATIONS

A. Calculate the “adjusted P_b” of the RAP to account for the addition of the 1 percent virgin asphalt binder as follows:

1. Calculate “mass of RAP Asphalt Cement (AC)”: 

   \[ \text{Mass of RAP AC} = \text{Dry RAP mass} \times P_b \]

2. Calculate “mass of virgin AC added”:

   \[ \text{Mass of virgin AC added} = 0.01 \times \text{Dry RAP mass} \]

3. Determine “New RAP mass”:

   \[ \text{New RAP mass} = \text{Dry RAP mass} + \text{Mass of virgin AC added} \]

4. Calculate “Adjusted P_b”:

   \[ \text{Adjusted P_b} = \frac{\text{Mass of RAP AC} + \text{Mass of virgin AC added}}{\text{New RAP Mass}} \times 100 \]

B. Calculate the effective specific gravity \((G_{se})\) of the RAP:

   \[ G_{se} (RAP) = \frac{(100 - \text{Adjusted } P_b)}{\left(\frac{100}{G_{mm}} - \frac{\text{Adjusted } P_b}{1.040}\right)} \]

C. Calculate the stone bulk gravity \(G_{sb}\) of the RAP:

   \[ G_{sb} (RAP) = G_{se} (RAP) - 0.100 \]
Liquid Binder

The method for determining the binder grade adjustment in HMA mixtures incorporating RAP is divided into three categories:

- Level 1; < 17% RAP AC / Total AC,
- Level 2; > 17% - 30% RAP AC / Total AC, and
- Level 3; > 30% RAP AC / Total AC.

\[
\text{RAP AC} = \% \text{ RAP} \times \% \text{ AC IN RAP}
\]
Multiple AC Types Demands Liquid Maintenance
Needs assessment…
HMA Return and Blue Smoke Mitigation
Flighting

- Combustion,
- Dryer flights,
- RAP protection vale.
CATERPILLAR

TECHNOLOGY
Innovation is standard with every Caterpillar product.

ACERT™ Technology
ACERT technology engines are now in Caterpillar Off-Road Machines.  » Learn More

Earth Moving Solutions
Discover Information Technology Products we offer made to improve machine operations.  » Learn More

Fleet Management Solutions
We offer technology product solutions  » Learn More

Ingenuity
What will you really remember most about today?
Thoughts?

Thoughts on the future…

Shall we make a list together on how to increase RAP usage or do you want me to pontificate? Use:

- Make \(1/4\)” clear stone to VMA and dust.
- Maintain VMA minimums.
- Encourage ingenuity; see DOT’s and APA / AGC.
Hot Mix Asphalt is
Smooth, Safe, and Long Lasting