Overview

- Introduction
- History
- Advantages
- Disadvantages
- Research Findings
- Conclusions
Partial List of Research Projects

- Ash (fly ash, bottom ash, MSW combustor ash)
- Fibers
- Fabrics
- Sludge (Wastewater)
- Industrial By-Products
- Hazardous Waste
- RAP
- RAS
- Many more!!
Good luck staying awake!!
Boy, when is this winter over??
What is a carbon footprint – definition

- The total amount of greenhouse gases produced to directly and indirectly support human activities
- Expressed in equivalent tons of carbon dioxide (CO2)
Home energy accounts for 21% of America's global warming pollution. If we make smart choices, we can cut more pollution than the entire emissions of over 100 countries!
As of 2 months ago (USA Today)

Carbon Dioxide Production

- China: 26%
- USA: 15%
- India
- Russia
- Japan
The developed world is 75% urban and the rate is accelerating in the developing world; By 2030 urban population is expected to rise to five billion or 60% of the world's population.
Future Problems??

- The developed world is 75% urban
- Rate is accelerating in the developing world
- By 2030: urban population is expected to rise to five billion or 60% of the world’s population
Human influence on the planet

- Population
- World Energy Consumption
- Water Pollution
- Biodiversity
- Invasive Species
- Protected Areas
- Air Pollution
Land Issues: Kansai International Airport, Osaka, Japan
Gibraltar Airport, Gibraltar: Between Morocco and Spain
Madeira International Airport
Maderia, Portugal
Don Mueang International Airport
Bangkok, Thailand: 18 hole golf course
Ice Runway: Antarctica: No asphalt and concrete runways!!
Congonhas Airport, Sao Paulo, Brazil
Courchevel International Air port
Courchevel, France: A hill?
Princess Juliana International Airport
Simpson Bay, Saint Maarten
Juancho E. Yrausquin Airport
Saba, Netherlands Antilles
Honduras!!
Dammam King Fahd International Airport, Dammam, Saudi Arabia: 300 sq miles; Bigger than Bahrain!!
Human influence on the planet

- Population
- World Energy Consumption
- Water Pollution
- Biodiversity
- Invasive Species
- Protected Areas
- Air Pollution
U.S. Infrastructure

- Over 2.3M miles of paved roads
- 94%: asphalt pavements
- 550 million tons of HMA used annually
- $20 billion in asphalt paving annually
Materials estimated to be in use in the National Highway System

- Nat'l Agg: 1500 M tons
- Cement: 48 M tons
- Asphalt: 35 M tons
- Steel: 6 M tons
U.S. Highway Statistics
(Growth Since 1970)

- Vehicle Miles Traveled (143%)
- Registered Vehicles (94%)
- Licensed Drivers (68%)
- Population (34%)
- Miles of Roads (6%)

Percent Increase Since 1970
Federal Highway System Costs

$13 billion spent each year on all federal highway projects.

FHWA: cost to bring our nation’s roads up to minimum engineering standards over the next 20 years: $565 and $655 billion.
Use of recycled materials in pavements can:

- Improve pavement performance
- Reduce initial costs
- Reduce lifecycle costs
- Provide useful disposal of waste without diminishing pavement performance
- Any combination of these
Types of Recycled Materials

- Reclaimed asphalt pavement (RAP)
- Shingle scraps
Reclaimed Asphalt Pavement (RAP)
Reclaimed Asphalt Pavement
U.S. RAP Production

83 million metric tons of RAP are produced in the U.S. each year

- 66 Million Metric Tons Recycled (80%)
- 17 Million Metric Tons Not Recycled (20%)
Reclaimed Asphalt Pavement

- Most recycled product in U.S. in both percentage (80%) and tonnage (66 million)
- Used so frequently in highway construction, it’s not considered a waste product
- All 50 states regularly utilize RAP in flexible pavements
- 10 states only use RAP in base and intermediate course mixtures (not surface course)
States Using RAP in All Types of Mixtures
Types of Pavement Recycling

- Surface recycling
  - In-place recycling to a depth of < 25 mm

- In-place surface and base recycling
  - In-place recycling to a depth of > 25 mm

- Central plant recycling
  - Most common form of pavement recycling
  - Only form to remove material from roadway before reuse
Material Considerations

- Physical Aspects
- Chemical Compatibility
- Present & Future Environmental Issues
- Views of Public, Engineers, & Decision Makers
- Life-Cycle-Cost Issues
- NEED information to make the “right call”
WOW!!
### RAP Data from Survey (Hansen and Newcomb 2011)

<table>
<thead>
<tr>
<th></th>
<th>Reported Tons Million</th>
<th>Total Estimated Tons Million</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2009</td>
<td>2010</td>
</tr>
<tr>
<td>Companies/branches Reporting Using RAP</td>
<td>189</td>
<td>189</td>
</tr>
<tr>
<td>Tons Accepted</td>
<td>23.2</td>
<td>24.0</td>
</tr>
<tr>
<td>Tons Used in HMA/WMA</td>
<td>20.1</td>
<td>21.6</td>
</tr>
<tr>
<td>Tons Used in Aggregate</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Tons Used in Cold Mix</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Tons Used in Other</td>
<td>0.1</td>
<td>0.07</td>
</tr>
<tr>
<td>Tons Landfilled</td>
<td>0.06</td>
<td>0.001</td>
</tr>
<tr>
<td>Avg. % for DOT mixes</td>
<td>12.5%</td>
<td>13.2%</td>
</tr>
<tr>
<td>Avg. % for Other Agency mixes</td>
<td>14.0%</td>
<td>15.2%</td>
</tr>
<tr>
<td>Avg. % for Commercial &amp; Residential</td>
<td>17.5%</td>
<td>18.0%</td>
</tr>
<tr>
<td>National Average All Mixes Based on % Reported For Different Sectors</td>
<td>15.6%</td>
<td>17.2%</td>
</tr>
<tr>
<td>National Average All Mixes Based on RAP Tons Used In HMA/WMA</td>
<td>16.2%</td>
<td>18.0%</td>
</tr>
</tbody>
</table>
NO RIGHT TURN

NO LEFT TURN
6:00am - 9:00am
MON - FRI
Advantages of RAP

- Saves landfill space
- Conserves virgin materials
- Lower cost without compromising performance
  - Use of RAP saves taxpayers $300M / year
- Decreased rate of aging
- Increased resistance to water damage
Research Results
Shingle Scraps
Never EVER complain about traffic

BECAUSE
Annual U.S. Shingle Scraps

9 Million Metric Tons: Roofing Demolition (90%)

1 Million Metric Tons: New Shingle Production (10%)
Shingle Scrap Composition

- Rock Granules: 63%
- Asphalt Cement: 32%
- Fiber and Other Materials: 5%

Diagram showing the composition of shingle scrap.
<table>
<thead>
<tr>
<th>Component</th>
<th>Organic Felt</th>
<th>Fiberglass Mat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt cement</td>
<td>30-36%</td>
<td>19-22%</td>
</tr>
<tr>
<td>Felt (Fiber)</td>
<td>2-15%</td>
<td>2-15%</td>
</tr>
<tr>
<td>Mineral aggregate (#30)</td>
<td>20-38%</td>
<td>20-38%</td>
</tr>
<tr>
<td>Mineral filler/stabilizer</td>
<td>8-40%</td>
<td>8-40%</td>
</tr>
</tbody>
</table>
Shingle Scraps

- Approximately 10 million metric tons produced annually in the U.S.
- Waste material from either roofing demolition or production of new shingles
- Used as a partial replacement for asphalt cement and fine aggregate in asphalt concrete mixtures
- Most shingle scraps used in asphalt mixtures are waste material from production of new shingles
Asphalt Shingle Recycling
Advantages of Shingle Scraps

- Reduced temperature susceptibility
- Increased rut resistance
- Reduced costs compared to conventional pavements
## RAS Data from Survey (Hansen and Newcomb 2011)

<table>
<thead>
<tr>
<th></th>
<th>Reported Tons Thousand</th>
<th>Total Estimated Tons Thousand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Companies/branches Reporting Using RAS</td>
<td>44</td>
<td>61</td>
</tr>
<tr>
<td>Tons Accepted</td>
<td>332</td>
<td>558</td>
</tr>
<tr>
<td>Tons Used in HMA/WMA</td>
<td>245</td>
<td>392</td>
</tr>
<tr>
<td>Tons Used in Aggregate</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Tons Used in Cold Mix</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tons Used in Other</td>
<td>39</td>
<td>34</td>
</tr>
<tr>
<td>Tons Landfilled</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>Avg. % for DOT Mixes</td>
<td>0.33%</td>
<td>0.78%</td>
</tr>
</tbody>
</table>
Texas: Assumptions Used for Asphalt Pavement Cost Estimates

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>COST PER TON</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>$22</td>
<td>Includes processing &amp; freight</td>
</tr>
<tr>
<td>PG 76-22</td>
<td>$538</td>
<td>Based on September 2009 *Index (freight not included)</td>
</tr>
<tr>
<td>PG 70-22</td>
<td>$480</td>
<td>Based on September 2009 *Index (freight not included)</td>
</tr>
<tr>
<td>PG 64-22</td>
<td>$377</td>
<td>Based on September 2009 *Index (freight not included)</td>
</tr>
<tr>
<td>RAP</td>
<td>$15</td>
<td>Contains 5% AC, includes processing &amp; freight</td>
</tr>
<tr>
<td>RAS</td>
<td>$20</td>
<td>Contains 20% AC, includes processing &amp; freight</td>
</tr>
</tbody>
</table>

*Source: Louisiana Asphalt Pavement Association*
Texas: Asphalt Pavement Cost Estimates

<table>
<thead>
<tr>
<th>Binder Grade</th>
<th>Virgin Mix</th>
<th>20% RAP</th>
<th>5% RAS</th>
<th>15% RAP+5% RAS</th>
<th>*One Grade Substitute</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG 76-22</td>
<td>47.80</td>
<td>41.24</td>
<td>42.54</td>
<td>37.64</td>
<td>35.74</td>
</tr>
<tr>
<td>PG 70-22</td>
<td>44.90</td>
<td>38.92</td>
<td>40.22</td>
<td>35.74</td>
<td>32.39</td>
</tr>
<tr>
<td>PG 64-22</td>
<td>39.75</td>
<td>34.80</td>
<td>36.10</td>
<td>32.39</td>
<td>NA</td>
</tr>
</tbody>
</table>

*Includes 15% RAP and 5% RAS*
On-going Research Project

- Nationwide survey: RAP/RAS
- Evaluate different cost calculations and pay items for each state
- Conduct an analysis of prices to estimate past cost savings to SCDOT and to compare prices between the Districts based on SCDOT’s data from various projects, including hot mix and warm mix asphalt mixtures.
- Develop a proposed pay schedule for aged binder versus virgin binder.
On-going Research Project (Cont’d)

- Develop pay schedule recommendations
- Develop a method of estimating the percent price reduction based on an increase in RAP/RAS content using both the existing pay schedule and the proposed pay schedule.
Theory is when you know everything but nothing works.
Practice is when everything works but no one knows why.
In our lab, theory and practice are combined: nothing works and no one knows why.
Issues to Consider

- Source of Shingles
- Consistency
- Size
- Gradation
- Contamination
- Percentages in the Mix
- Fatigue
BOULEVARD HAUSSMAN, PARIS
A WOMAN WAS CONFUSED BETWEEN THE SUBWAY AND A PARKING. VERY NORMAL.
TWO HOURS LATER... THE POLICE CLEARED THE ENTRANCE
Conclusions

- Environmental Issues
- Cost Issues (Initial and LCCA)
- Compatibility Issues
- Recycling of the New Pavement
- Public Perceptions
- Acceptance by Governmental Agencies
The developed world is 75% urban and the rate is accelerating in the developing world; By 2030 urban population is expected to rise to five billion or 60% of the world's population
Just in case nobody has Smiled at you today...
Wake up, he is done!!
Thank you!!