Presentation Overview

- Basic information about FHWA and the USA’s Highway Transportation Network.
- FHWA’s Recycling Policy
- Pavement and Materials Technology Opportunities in Transportation Applications:
  - Recycling
  - Reuse
  - Other Technologies
- Resources that might help your work!
The Use of Industrial Materials in Highway and Road Construction
Office of Asset Management, Pavement and Construction

4 Teams

- Design and Analysis
- Materials
- Construction
- Asset and Pavement Management

New –
Office of Program Performance Management
also with 4 New Teams

The Use of Industrial Materials in Highway and Road Construction
The Use of Industrial Materials in Highway and Road Construction
The Use of Industrial Materials in Highway and Road Construction
Without Pavement, We Would Be Stuck in the Mud!
Society Depends on Infrastructure

INFRASTRUCTURE

ROADS, BRIDGES, AIRPORTS, WATER SYSTEMS, WASTEWATER SYSTEMS, GAS, ELECTRIC, TELEPHONES, WATERWAYS, COASTAL FACILITIES, PARKS, ETC.

ECONOMIC TRANSACTIONS

SOCIAL INTERACTIONS

The Use of Industrial Materials in Highway and Road Construction
2007 Average US Household Expenditures 18% for Transportation
Less Than 100 Years Ago...

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We’ve Come a Long Way …

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4 Million Miles of Roads
600,000 Bridges
Statistics We Should Know:

Federal  = 3%
State    = 20%
Local    = 77%

2/3 are Paved (1/3 Unpaved)
94% of Paved have an Asphalt Surface
FHWA’s “3 E’s”

**ENGINEERING**
- Use Good Engineering Design to Assure Long-Life Pavements.

**ECONOMICS**
- Use Life-Cycle Cost Analysis for Project Selection.

**ENVIRONMENT**
- Consider Recycling First
- Be Good Stewards of the Environment
FHWA Recycled Materials Policy

- FHWA recognize the need to increase our highway industry's overall use of recycled materials
- Forge partnerships among government, industry, and academia
- Continue to strengthen the relationship between FHWA, US EPA, and State DOT/DEQ

www.fhwa.dot.gov/legsregs/directives/policy/recmatmemo.htm
Key Points of FHWA Recycling Policy

- Recycled materials should get first consideration in overall materials selection.

- Recycling can offer engineering, economic and environmental benefits.

- Engineering and environmental properties are important.
Key Points of FHWA Recycling Policy

- Life Cycle Cost benefits assessment is warranted for economic consideration.
- Restrictions prohibiting recycled material that are without technical basis should be removed.
- RCRA applies to Federal-Aid projects
  - Resource Conservation and Recovery Act
  - [www.epa.gov/epawaste/inforesources/online/index.htm](http://www.epa.gov/epawaste/inforesources/online/index.htm)
WHY FHWA Promotes Recycling?

- Environmental Enhancements and Stewardship
- Economic Savings Potential
- Performance Enhancements
- Saving “Non-Renewable” Resources
- Cooperative Partnerships with Industry
- Just “Darn Good” Practice
Presentation Overview

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  - Other Technologies
- Resources that might help your work!
EPA Mantra

- **REDUCE**
  - Consume Less If Possible.

- **RECYCLE**
  - Reuse Previously Produced Materials.

- **REUSE**
  - Incorporate Materials Used in Other Manufacturing Processes Into the Work.

*The Use of Industrial Materials in Highway and Road Construction*
The Use of Industrial Materials in Highway and Road Construction

TECHNOLOGY APPLICATIONS

- RECYCLING
  - Reclaimed Asphalt Pavement
  - Recycled Concrete Aggregate
  - In-Place Recycling

- REUSE
  - FLY ASH / COAL ASH
  - TIRE RUBBER
  - SHINGLES
  - SLAG
  - FOUNDRY SAND

- Warm-Mix Asphalt
Recycling Applications

- Reclaimed Asphalt Pavement
- Recycled Concrete Aggregate
- In-Place Recycling
The Use of Industrial Materials in Highway and Road Construction

Materials Recycling – Tons/Year

- Asphalt pavement: 80.3 million tons
- Scrap steel: 70 million tons
- Newsprint: 6.2 million tons
- Concrete pavement: 3.3 million tons
- Glass bottles: 2.9 million tons
- Aluminum cans: 0.9 million tons
- Lead-acid batteries: 0.8 million tons
- Magazines: 0.5 million tons
- Plastic containers: 0.3 million tons

Source: APA
The volume of recycled asphalt pavement is:

- 13 TIMES greater than recycling of newsprint
- 27 TIMES greater than recycling of glass bottles
- 89 TIMES greater than recycling of aluminum cans
- 267 TIMES greater than recycling of plastic containers

Source: APA
What is RAP?

Aggregate ~ 95%

Asphalt Binder ~ 5%
Costs / Values of RAP

- Value = Material it replaces - processing
  - Aggregate - 95% at $10/ton = $9.50
  - Asphalt - 5% at $400/ton = $20
  - Minus the Processing = $5/ton

  Total Value = $24.50 per ton

- 10% RAP saves $2.45/ton
- 20% RAP saves $4.90/ton
- 40% RAP saves $9.80/ton
Sustainability Considerations

30,000 Tons of RAP = 70 - 6,000 Gallon Transport Trailers and 28,200 Tons of Clean Aggregate

Courtesy: Astec Industries

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Recycled Concrete Aggregate
2004 FHWA RCA Review

Survey and In-Depth Review of:
- Texas
- Virginia
- Michigan
- Minnesota
- California

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States using RCA as Base

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States using RCA in PCCP

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Worlds Largest “Urban Quarry”

Courtesy of Recycled Materials, Inc.

Denver 8.5 miles
World’s 2nd Largest Recycle Project!

El Toro MCAS
Irvine, California

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Aggregate Hauling is longer...
FHWA / ARRA WORKSHOPS

- 2008 – Salt Lake City, UT
- 2009 – Minneapolis, MN
- 2010 – Harrisburg, PA
- 2011 – Atlanta, GA

http://www.pavementpreservation.org/conferences/regional-in-place-recycling-conferences/
Cold In-Place Recycling

Description
Milling, rejuvenating, and replacement of the top portion of the HMA surface (performed without heat)

Purpose
Rework HMA to depth of 2 – 4 inches.
Correct surface distresses.
Improve profile, crown, and cross-slope.
The Use of Industrial Materials in Highway and Road Construction

Nevada DOT CIR

Lime Slurry

CIR Train

Milling

Milling Teeth

Vibratory Roller

Processed Material
Hot In-Place Recycling

Description
Milling, rejuvenating, and replacement of the top portion of the HMA surface (performed with heat)

Purpose
Rework HMA to depth of 1 to 2 inches.
Correct surface distresses.
Improve profile, crown, and cross-slope.
TECHNOLOGY APPLICATIONS

✓ Reclaimed Asphalt Pavement
✓ Recycled Concrete Aggregate
✓ In-Place Recycling

REUSE APPLICATIONS

- FLY ASH / COAL ASH
- TIRE RUBBER
- SHINGLES
- SLAG
- FOUNDRY SAND

Use of Emulsions / Warm-Mix Asphalt
Fly Ash – Substitute for Cement

Essential Component for Durable Concrete
Fly Ash – Substitute for Cement

• Approximately 50% of US electricity is generated by coal-fueled power plants
• In 2003, over 110 million metric tons of CCP were produced
• 38% beneficially used (42 mill. metric tons)
Controlled Low Strength Material

CLSM using Class F fly ash

CLSM using Class C fly ash and sand

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Soil Stabilization

Increase the structural capacity of sub-grades and road base.
Coal Combustion Products (CCP)

- Fly Ash in:
  - PCC
  - Stabilization of base course
  - Flowable fill
  - Structural fills/Embankments
  - Soil improvements
  - Asphalt pavements
- Flue Gas Desulphurization (FGD)
- Bottom Ash
TIRES

What Can We Do With This Mess Resource?
- 300 million more are added annually.
- 87% currently going to an end-use market
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Tire Bales

- Block of Rubber
  - 2.5’x 4.5’x 5’
  - 2000 pounds
- 60% weight reduction over soil
- Permeable
- USES:
  - Embankments.
  - Slope repair and rock fall barriers.

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Ground Tire Rubber

- Performance Properties
  - Cost effectiveness
  - Added Benefit
- User Demands
  - Noise abatement
- Sustainability
  - Recyclable in HMA?

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Asphalt Roofing Shingles

- Factory rejects are recycled into high-quality pavements.
- Approved for use by North Carolina and Minnesota DOTs.
- **10 MILLION TONS/YR REMOVED FROM ROOFS – MOST ARE LANDFILLED!**
Slag - Reuse

- A by-product of steel production
  - Works especially well as Aggregate for high-volume roadways and/or
  - High skid-resistance applications
    - Indianapolis Motor Speedway
    - Automobile manufacturers’ test tracks
  - Meets requirements for use in Superpave Aggregates
Foundry Sand - Reuse

- Already screened, blended and ready to use in Hot Mix Asphalt
  - Reduces cost of sand by about 40%
  - 100,000 tons used in HMA per year
Foundry Sand

- Structural Fills & Embankments
- Flowable Fills – pipe/trench backfill
- Roadway Base material
- Cement feed stock
  - Fine Aggregate for PCC
- Hot Mix Asphalt aggregate
- Soil Amendment

The Use of Industrial Materials in Highway and Road Construction
### Reuse of Industrial Byproducts

Millions of Tons per Year used in Highway Applications

<table>
<thead>
<tr>
<th>Byproduct Materials Produced</th>
<th>Production (million metric tons)</th>
<th>Recycled in Highway Applications (million metric tons)</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast Furnace Slag</td>
<td>14</td>
<td>12.6</td>
<td>Concrete</td>
</tr>
<tr>
<td>Coal Bottom Ash</td>
<td>14.5</td>
<td>4.4</td>
<td>Asphalt, Base</td>
</tr>
<tr>
<td>Coal Fly Ash</td>
<td>53.5</td>
<td>14.6</td>
<td>Cement Production, Structural Fill</td>
</tr>
<tr>
<td>Foundry Sands</td>
<td>9 to 13.6</td>
<td>?</td>
<td>Flowable Fill, Asphalt</td>
</tr>
<tr>
<td>Cement Kiln Dust</td>
<td>12.9</td>
<td>8.3</td>
<td>Stabilizer</td>
</tr>
<tr>
<td>Bottom Ash</td>
<td>8</td>
<td>Small Amounts</td>
<td>Asphalt, Base</td>
</tr>
<tr>
<td>Nonferrous Slags</td>
<td>8.1</td>
<td>?</td>
<td>Base, Asphalt</td>
</tr>
<tr>
<td>Steel Slags</td>
<td>?</td>
<td>7.5</td>
<td>Base, Asphalt, Concrete</td>
</tr>
<tr>
<td>Recycled Asphalt Pavement</td>
<td>41</td>
<td>33</td>
<td>Asphalt, Base</td>
</tr>
<tr>
<td>Reclaimed Concrete</td>
<td>?</td>
<td>?</td>
<td>Base, Concrete</td>
</tr>
</tbody>
</table>

The Use of Industrial Materials in Highway and Road Construction
Technology Applications

- Reclaimed Asphalt Pavement
- Recycled Concrete Aggregate
- In-Place Recycling
- REUSE APPLICATIONS
  - TIRE RUBBER
  - SHINGLES
  - SLAG
  - FOUNDRY SAND

Use of Emulsions and Warm-Mix Asphalt
The Use of Industrial Materials in Highway and Road Construction

Energy Use Comparisons

- Emulsions
  - Cold Mix
  - Warm Asphalt
  - RAP
  - WMA
  - HMA

Temperature, °F

Fuel/Ton

Courtesy of NAPA/COLAS

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Emulsions

Asphalt Emulsions

Water and Emulsifying Agent

Asphalt Globules
The Pavement Preservation Concept

Original Pavement

Rehabilitation Trigger

Very Good

Good

Fair

Poor

Very Poor

Time (Years)
Warm Mix Asphalt Benefits

- Savings in energy
- Decreased plant emissions
- Reduced exposure to fumes
- Low/No odor

- Improved compaction
- Extended haul distances
- Extended paving season
- Higher RAP incorporation
- SAFETY
- Longer binder life?

www.warmmixasphalt.com
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States Using Recycled Materials

- RAP
- Tires
- Slag
- Plastic
- Concrete
- Wood Waste
- Glass
- Ceramics
- Compost
Resources for Agencies

- FHWA
- OTHER ORGANIZATIONS
- WEBSITES
- READING RECOMMENDATIONS
- COLLEAGUES / PARTNERS
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FHWA Web-Based Resources

- www.fhwa.dot.gov/pavement/recycle
- www.fhwa.dot.gov/preservation
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FHWA Supports Pavement Preservation!

Left to right: Associate Administrator for Infrastructure King Gee; Administrator Tom Madison; James B. Sorenson, Highway Engineer; and Executive Director Jeff Paniati.
FHWA Supports Pavement Recycling!

*The Use of Industrial Materials in Highway and Road Construction*
Key Websites – 1/2

- FHWA Pavement Recycling –
- FHWA INVEST Tool: “Infrastructure Voluntary Evaluation Sustainability Tool”
  http://www.sustainablehighways.org/
- Asphalt Recycling and Reclaiming Association
  http://www.arra.org
- Pavement Recycling and Reclaiming Center
  http://prrcenter.org (Cal Poly Pomona)
Key Websites – 2/2

- FHWA Every Day Counts Warm Mix Asphalt
  http://www.fhwa.dot.gov/everydaycounts/technology/asphalt

- Recycled Materials Resource Center -
  http://www.recycledmaterials.org

- Green Highways Partnership
  http://www.greenhighways.org

- USEPA Resource Conservation Challenge
  http://www.epa.gov/osw/conserve/rrr/imr/index.htm

The Use of Industrial Materials in Highway and Road Construction
Recommended Reading

  User Guidelines for Byproducts and Secondary Use Materials in Pavement Construction

- [http://www.dot.state.co.us/Publications/PDFFiles/epagrant.pdf](http://www.dot.state.co.us/Publications/PDFFiles/epagrant.pdf)
  MATERIALS RECYCLING AND REUSE – FINDING OPPORTUNITIES IN COLORADO HIGHWAYS, October 2007
Concluding Comments

- Resources for State and Local Agencies
  - Industry Associations: AEMA, ARRA, ISSA, FP2
  - National Center for Pavement Preservation
  - Recycled Materials Resource Center
  - FHWA websites, publications, products, training
  - TRB, NCHRP, AASHTO
  - Webinars
  - Training: NHI, Workshops

- How do we measure success?
Challenge for YOU!

- **Do**
  - Look at your current specs/regulations
  - Overcome your own hurdles
- **Act**
  - Partner with DOT/ DNR / EPA & Industry
  - Create reuse/recycle programs
  - Make use of the resources noted in this presentation!

*The Use of Industrial Materials in Highway and Road Construction*
Partnerships Are Required

- FHWA
- Academia
- State DOTs
- Local Governments
- Private Sector

The Use of Industrial Materials in Highway and Road Construction
Partnerships are Required

- 1 FHWA
- 52 State DOTs (including DC and PR)
- 3,034 County governments;
- 35,933 Municipal, Town and Township governments.
- 4,140 Colleges and Universities
- ___ contractors/industry reps.

UNITED WE STAND....
It’s Good to be GREEN!

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