Greening the Blacktop: RAP, porous (OGFC), Warm Mix

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

...many programs

(many environmental sustainability)

...many terms

Carbon footprint

Green building

USGBC LEED

Green Highways Partnership

Stewardship, Safety, & Sustainability

Continually changing technology...
Surviving in a Green Environment

Issues
- Green building practices are being required
- Concrete mis-information via testimony
- Water Quality: Asphalt = OIL
- Pavement LCA and GHG / carbon footprint

Facts
- Asphalt pavements = green pavements
  - Safer, quieter, speed of construction
  - Manages stormwater runoff
  - Accepts recycled goods
  - Low energy to construct / low carbon footprint
Green building practices are being required federal, state, even residential requirements. Reflective roofs, impervious taxes, LEED certification at increasing levels, pavement material identified, NAPA's LEED brochure.

An image showing the LEED process developed by USGBC. It is a national benchmark for design, construction, and operation of "green" buildings. The five key areas are: Sustainable site development, Water efficiency, Energy efficiency, Materials selection, Indoor environmental quality. Earning LEED certification must meet certain criteria - credits certification process. Levels based on total credits. How asphalt pavements contribute to LEED credits.

A diagram showing the LEED for new construction distribution by geography.

A chart showing LEED certification levels by possible points:
- Sustainable Sites: 16
- Water Efficiency: 5
- Materials Resources: 13
- Energy Atmosphere: 17
- Indoor Environ. Quality: 14
- Innovation & Design: 5


5 credits.
### Materials & Resources

<table>
<thead>
<tr>
<th>Credit</th>
<th>Description</th>
<th>Possible Points</th>
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<tbody>
<tr>
<td>1</td>
<td>Storage &amp; Collection of Recyclables</td>
<td>Required</td>
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<tr>
<td>2</td>
<td>Building Demolition: Minimize 75% of Existing Wals, Doors &amp; Roof</td>
<td>1</td>
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<tr>
<td>3</td>
<td>Building Demolition: Minimize 50% of Existing Wals, Doors &amp; Roof</td>
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<td>4</td>
<td>Cont. Waste Management: Divert 5% from Disposal</td>
<td>1</td>
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<tr>
<td>5</td>
<td>Cont. Waste Management: Divert 10% from Disposal</td>
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</tr>
<tr>
<td>6</td>
<td>Materials Sense: 8%</td>
<td>1</td>
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<tr>
<td>7</td>
<td>Materials Sense: 12%</td>
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<tr>
<td>8</td>
<td>Recycled Content: 20% (post-consumer + 12 pre-consumer)</td>
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<tr>
<td>9</td>
<td>Recycled Content: 30% (post-consumer + 12 pre-consumer)</td>
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<tr>
<td>10</td>
<td>Region Materials: 10% Energy, Process &amp; Manufacturing Reaps</td>
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</tr>
<tr>
<td>11</td>
<td>Region Materials: Retrieved, Processed &amp; Manufactured</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>Rigid Pavement</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>Certified Wood</td>
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</tbody>
</table>

### Sustainable Sites: 16 Possible Points

- Sustainable Sites: 16 Points
- Water Efficiency: 5 Points
- Materials & Resources: 13 Points
- Energy & Atmosphere: 17 Points
- Indoor Environ. Quality: 14 Points
- Innovation & Design: 5 Points

### LEED credit for asphalt

- SS Credit 6.1: SW Design: Quantity Control
  - Porous Asphalt
  - 1 Credit

- SS Credit 6.2: SW Design: Quality Control
  - Porous Asphalt
  - 1 Credit

- SS Credit 7.X: Heat Island Effect: Non-Roof
  - Reflective Surf. OGFC, Porous
  - 1 – 3 Credits

- MR Credit 2.X: Const. Waste Mgt. Divert from disposal
  - RAP
  - 1 – 2 Credits

- ID Credit 1.X: Exceptional perform./areas not addressed
  - WMA
  - High RAP
  - 1 – 4 Credits

### Issue

- Green building practices are being required
  - Federal, state, even residential requirements
  - Impervious taxes
  - Green building practices at increasing levels

### Facts

- Reflective roofs
- Impervious taxes
- LEED certification at increasing levels
- Pavement material identified
- NAPA brochure

### LEED process

- Familiarize yourself with green-building lingo
- Seek-out green-building Stakeholders
  - (landscape) architects, developers
  - Municipal leaders
- Promote “common-sense” vs LEED criteria
  - Municipalities have leeway to define “green”
  - RAP and OGFC/porous pavement are GREEN
  - Recycle, safety, noise, water quality, WMA
  - NAPA advocating LEED credit for recycle / reuse

### Issue

- Concrete mis-information via testimony
  - ACPA provided slanted testimony
  - Questioned longevity of asphalt
  - Promoted 100% recycled concrete
  - Promoted lowest energy footprint
  - More fuel to drive on / construct asphalt
  - Asphalt pavements contribute to UHI
  - Promoted “green” criteria for pavement selection

### Setting the record straight

- Copies of NAPA’s testimony available
"... but in reality concrete pavements generally last much longer, while asphalt pavements last less than 20 years."

Facts:
- Asphalt pavements can last indefinitely
  - Lower lifetime cost
- Perpetual pavements
  - Designed for life
  - Minimum rehabilitation

ACPA Assertion
"Concrete is 100 percent recyclable and reusable."

Facts:
- "Reused" for the same purpose is the key vs merely "recycled"
- Asphalt can be reactivated / reused
  - Cement can not
- RAP is "reused" back into pavement
  - Concrete - low quality aggregate at best

Reclaimed Asphalt Pavement “RAP”
- Removed and/or reprocessed pavement materials containing asphalt and aggregates
- Over 80 percent of the asphalt pavement, removed each year for widening and resurfacing, is re-used
- Represents close to 100 million tons / year
- RAP is the Nation’s No. 1 recycled material in both total amount and percentage recycled

Common Recycled Materials in Asphalt Pavements
- Shingles
- Crumb / Tire Rubber
- Glass
- Slag
- Foundry sand
- All are in different stages of utilization / evaluation

Shingle materials already used in HMA
- > 20% asphalt binder
- Fibers
- Sand
- Usually 5% of mix
- Saves 1% binder > $6.00 ton
- Primarily from Mfg. Waste
- Tear-offs
  - Concern about asbestos
  - Not used since early 80’s
- 27,000 samples ~1% detected
Over the past two years, MoDOT has allowed contractors to put used shingles that have been removed from rooftops into their asphalt mix. The result is a very durable, more-rut resistant asphalt at a much lower price.

The use of recycled shingles saves $3 to $5 per ton of asphalt. That may not sound like much at first, but consider this: a typical resurfacing project would use about 30,000 tons of asphalt, for a savings of $90,000 to $150,000.

ACPA Assertion

“Concrete has been used successfully... to reduce urban heat island effect...

the potential energy savings in the [US]... is estimated at $5 billion per year through reduced cooling costs.

At this time urban heat island is not a factor used in the selection of pavements by FHWA or state transportation departments.”

Myth

- Asphalt pavements contribute to UHI
- Concrete pavements are cooler than asphalt

Fact

- The “built” environment contributes to UHI
- OGFC pavements are cooler than concrete
- The hottest location in Phoenix is the airport - 23 inches of PCC

Urban Heat Islands

Pavement Temperatures vs. Albedos

reflectivity & temperatures
Cooler Pavements → Cooler Air

Los Angeles: Simulate change of all pavement albedos (in < 20 years of normal maintenance)

- **Input:**
  - Albedo change = 0.25
  - Pavement area = 1,250 km²
  - Urban area = 10,000 km²
  - Normal LA weather

- **Result:**
  - Decrease in air temperature = 0.6°C (1°F)

**why is this important?**

**cooler pavements**
Concrete pavement reduces fuel consumption by up to 7% saving the trucking industry over $6.3 Billion annually and reducing CO2 emissions by 15 million tons.

Flexible asphalt pavements cause deflection allowing energy to be absorbed and increasing fuel consumption.

**Myth**
- Smoothness, NOT pavement type, is determinant for pavement fuel consumption
- Test sections were NOT equivalent between asphalt and concrete pavements
- Some of the findings were NOT favorable to the concrete industry
- Auto fuel consumption was better with asphalt pavements compared to concrete
- Study, sponsored by cement industry, still concluded that their findings couldn’t be used

**Fact**
- Smoothness, NOT pavement type, is determinant for pavement fuel consumption
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- Roughness and grade were not matched
- Some of the findings were NOT favorable to the concrete industry
- Auto fuel consumption was better with asphalt pavements compared to concrete
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**ACPA Assertion**
- “Concrete pavements inherently have the lowest overall energy footprint. The primary factors are . . . that [concrete] is not a byproduct of petroleum refining and thus has a much lower embodied . . . energy . . . . .
  Construction of hot-mix asphalt roadways consumes more than five times as much diesel fuel as the construction of comparable concrete roadways.”

**ACPA Assertion**
- “… study demonstrated . . . significant fuel savings . . . on concrete versus asphalt pavements
  . . . if these asphalt surfaces were converted to concrete surfaces, it would save 2.1 billion gallons of diesel fuel per year . . . $8.2 billion dollar[s] . . .
  . . . reduce our dependence on oil, lower the emissions from vehicles, and decrease the cost of transporting goods”

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“energy footprint” ≠ “carbon footprint”
- Fuel consumption vs GHG emission
- Cement / concrete vs HMA CO2
- Construction energy approx. equal
- Production energy may be higher w/ HMA
- “embodied energy” vs “sequestered”
- Permanently removed and reused
- Concrete LOSES re GHG / CO2 emissions
- But cement process is making progress
- Total life cycle carbon footprint is key

The total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO2).

Assumptions
10 Hour job
12.5 miles from the plant
250 Truck trips
- Producing HMA Generates 40 tons of CO2
- Delivering HMA Generates 107 tons of CO2
- Placing HMA Generates 3.3 tons of CO2
- Total “emissions” = 151 tons of CO2

Do it all over again!

Materials extraction
Materials processing
Materials transport
HMA production
HMA transport
HMA prep
HMA placement
Interim maintenance

Assumptions
10 Hour job
12.5 miles from the plant
250 Truck trips
- Producing HMA Generates 40 tons of CO2
- Delivering HMA Generates 107 tons of CO2
- Placing HMA Generates 3.3 tons of CO2
- Total “emissions” = 151 tons of CO2

Fact
- “energy footprint” ≠ “carbon footprint”
- Avg. HMA plant emits ~ 2,500 tons CO₂
- Avg. automobile emits ~ 6 tons CO₂ annually
- 2,500 tons = ~ 0.0023 Tg (MMTons)
- Cement industry emits ~ 77 Tg CO₂
- Over 300 times more CO₂ emission per plant
- When comparing “carbon footprint”; HMA pavement unit @ ~ 30% vs. PCC concrete (BEES)
- So, where is HMA industry vs. all GHG emissions

![Diagram of CO₂ emissions comparison](image1)

**Global Warming by Life-Cycle Stage**

- HMA
- High Modulus HMA
- HMA w/ 15% RAP
- WMA will reduce
- Reduction w/ 15% RAP
- **BEES**

**BEES: econ. & env. impacts**

- **BEES 4.0**
  - BEES: environmental sustainability software tool for life cycle assessment and environmental impact analysis
  - **BEES** provides a comprehensive tool for evaluating the environmental impacts of construction materials and systems
  - Covering a wide range of environmental impacts, including climate change, water consumption, and land use

- **Energy consumption**
  - **HMA**
  - **High Modulus HMA**
  - **HMA w/ 15% RAP**
  - **WMA will reduce**
  - **Reduction w/ 15% RAP**

- **Greenhouse gas emissions**
  - **BEES** assesses greenhouse gas emissions across the entire life cycle of construction materials and systems
  - Covering a range of emissions, including carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O)

**Note:** Lower values are better

![Diagram of energy consumption](image2)

![Diagram of greenhouse gas emissions](image3)
The entire annual CO2 / greenhouse gas emissions / carbon footprint from a typical hot-mix plant (~ 2,500 tons) could be totally offset by using ~ +/- 30% RAP in pavement mix designs -- accomplished by minimizing acquisition of energy intensive (natural) raw materials such as aggregate and petroleum asphalt.

RAP: sustainable & carbon neutral

Impervious pvmt – driving green

stormwater management

Porous Pavement with Recharge Bed

stormwater management

2008 SEAUPG CONFERENCE-BIRMINGHAM, ALABAMA
Many different technologies
- Additives such as waxes and zeolites
- Emulsions and water foaming processes
- Costs differ; some higher, some lower
- End-result: to lower mix temperatures from 300°F to 250°F (or lower)
- Less energy demand / fuel consumption
- Less emissions: plant and field
- Quantifying energy and emissions
  - ~ 15% less fuel consumption / CO2 emissions
- Lower NOx, particulate, other emissions
- States, Producers, Contractors, FHWA all interested
- Will dominate market < 5 years
- Compatible in congested areas (emissions / community)

Reducing fuel consumption is win-win – saves $$$
Reducing field emissions improves the workplace and public’s perception of asphalt paving
Reducing plant odor improve community relations
Reducing plant emissions is also worth $$$
  - May encourage higher production rates – how?
  - Might be traded (e.g., NOx, CO2)
  - Will be attractive to a State’s Implementation Plan (SIP)
  - Allows state to meet Fed obligations easier
  - Helps in non-attainment areas
  - E.g., NJ requiring LNBs @ $150K + op costs

ASPHALT: the environmentally sustainable pavement
- Porous pavements manage stormwater
- OGFCs are safe, quiet, and better roadway
- Reflective / OGFC / Porous can mitigate UHI
- Great pavement to help LEED certification
- Asphalt pavements accept recycled / #1 recycled RAP
- WMA pavements are environmentally preferred
  - Lower carbon footprint, speed of construction
- Warm Mix lowers energy consumption / emissions
- RAP can offset entire annual HMA GHG emissions

WMA is win-win
- "Warm Mix Asphalt (WMA)"
- "Greening the blacktop"
Questions

"It ain't easy being green!"

Long Life

- Lower Life Cycle Cost
  - Better Use of Resources
  - Low Incremental Costs for Surface Renewal
- Lower User Delay Cost
  - Shorter Work Zone Periods
  - Off-Peak Period Construction

Rehabilitation

- 20+ Years Later

Pavement Foundation

Max Tensile Strain

Solutions

- Mill & Fill
- Thin Overlay
- Use for RAP

High Quality SMA, OGFC or Superpave

Rut Resistant Material

Flexible Fatigue Resistant Material

40-75 mm SMA, OGFC or Superpave

High Modulus Rut Resistant Material (Varies As Needed)

Zone of High Compression

150 mm to 150 mm

High Modulus Rut Resistant Material

2008 SEAUPG CONFERENCE-BIRMINGHAM, ALABAMA
Vehicles on highways generate a significant amount of noise.
- Noise from the tire/pavement interface accounts for over 75% of the vehicle noise.
- Sound-walls are expensive and are only somewhat effective if placed in the line-of-sight.
  - They reduce noise minimally and only over certain distances from the roadway.
  - Sound-walls can increase UHI effects because they decrease air movement across pavement surface.
- Traffic Noise can be significantly reduced using Open-Graded Friction Courses (OGFC).

Noise Reduction: AR-OGFC on Highway

Surface Chip Seals and Coatings:
- Using reflective / light-colored chip / paints.

“Gritting”:
- Reflective chips and aggregate.

Shot-Blasting:
- Abrading surface binder.
Synthetic and Colored Binders:
using reflective aggregates

Synthetic / Colored Binders:
using reflective / colored aggregates

Using Asphalt Pavement to Reduce UHI
- Albedo doesn’t appear to be the entire story
- The role of thickness, density, and porosity are being evaluated to understand pavement’s heat sink capacity
- Other “BMPs” have been identified to help mitigate pavement surface temperature (trees, topography)
- OGFC / porous pavements have been shown to be highly effective in reducing pavement surface temps
- Reflective HMA pavements can be produced $$
- But . . . IMHO . . .
- Pavement design has “net zero” balance on UHI temps
- USGBC needs to understand this . . .

Asphalt pavement is positioned nicely
- Recycled (re-used) and recyclable
  - Innovation credit every 5% more than 10% / 20% reused / recycled – petition USGBC LEED
- Local materials
- Stormwater management
- UHI: need to work through the “process”
  - Comfort issue under limited circumstances
  - Porous pavmts / OGFC might mitigate – petition
  - Asphalt reflective pavements can be produced