Sustainable Highway Construction Practices

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Sustainable highway construction practices

what is sustainability?

why sustainability?

what is being done in highways?

Sustainable highway construction practices

local connection

strategies

moving forward

assessment
What's the big deal?
Definitions
Formerly one of the four largest lakes in the world with an area of 68,000 square kilometers (26,300 sq mi), the Aral Sea has been steadily shrinking since the 1960s after the rivers that fed it were diverted by Soviet irrigation projects.

By 2007, it had declined to 10% of its original size.
Deforestation in Kalimantan Indonesia
Desertification –
Impact on Hydrological Cycle

- Drought → Less vegetation → Erosion
- Less percolation to groundwater (slower recharge)
- Exposed soil: Baked by sun, Sealed by rain
- More evaporation, Increased runoff

Threatens 1/3 of the earth's land surface.
Threatens the livelihoods of one billion people.
Has already made 135 million people homeless.
Twenty four billion tons of fertile soils disappear every year.
Threatens 40% of Asia, from the Mediterranean coast to the shores of the Pacific.
Number of Cars By Region In Millions

EXPLANATION

- West Asia
- North America
- Latin America and the Caribbean
- Europe and Central Asia
- Asia and the Pacific
- Africa

Total

- Total = 676.2
- Total = 541.7
- Total = 391.1

NUMBER OF MOTOR VEHICLES, BY REGION, IN MILLIONS

- 1980:
  - Total = 262.8
  - West Asia = 2.3
  - North America = 184.7
  - Latin America and the Caribbean = 17.4
  - Europe and Central Asia = 129.1
  - Asia and the Pacific = 52.3

- 1990:
  - Total = 391.1
  - West Asia = 44.2
  - North America = 208.6
  - Latin America and the Caribbean = 191.0
  - Europe and Central Asia = 93.2
  - Asia and the Pacific = 127.3

- 1996:
  - Total = 676.2
  - West Asia = 5.5
  - North America = 44.2
  - Latin America and the Caribbean = 256.5
  - Europe and Central Asia = 127.3
  - Asia and the Pacific = 18.6
  - Africa = 6.4
Construction Materials

We have **finite resources** and we are extracting more and more to satisfy an increasing population and standard of living.
Number of earths needed to sustain such development
Promise of such economic development is unrealizable without dramatic change in our approaches and management systems...
Engineering activities have impacts that need to be balanced.
1. concentrations of substances extracted
2. concentrations of substances produced
3. degradation by physical means
4. people’s ability to meet needs not undermined
Measurement Methods
Evaluating Sustainability
ASU Fulton Center

LEED Certified

4 certification levels
- Platinum > 80 points
- Gold 60–79 points
- Silver 50–59 points
- Certified 40–49 points
<table>
<thead>
<tr>
<th>Sustainable Sites</th>
<th>Possible Points: 26</th>
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<tbody>
<tr>
<td><strong>Y</strong> Proreq 1</td>
<td>Construction Activity Pollution Prevention</td>
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<tr>
<td>Credit 1 Site Selection</td>
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<td>Credit 2 Development Density and Community Connectivity</td>
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<td>Credit 3 Brownfield Redevelopment</td>
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<tr>
<td>Credit 4.1 Alternative Transportation—Public Transportation Access</td>
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<tr>
<td>Credit 4.2 Alternative Transportation—Bicycle Storage and Changing Room</td>
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<tr>
<td>Credit 4.3 Alternative Transportation—Low-Emitting and Fuel-Efficient Ve</td>
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<tr>
<td>Credit 4.4 Alternative Transportation—Parking Capacity</td>
<td>2</td>
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<tr>
<td>Credit 5.1 Site Development—Protect or Restore Habitat</td>
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</tr>
<tr>
<td>Credit 6.1 Stormwater Design—Quantity Control</td>
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<tr>
<td>Credit 6.2 Stormwater Design—Quality Control</td>
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<tr>
<td>Credit 7.1 Heat Island Effect—Non-roof</td>
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<tr>
<td>Credit 7.2 Heat Island Effect—Roof</td>
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<tr>
<td>Credit 8</td>
<td>Light Pollution Reduction</td>
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<table>
<thead>
<tr>
<th>Materials and Resources, Continued</th>
<th>Possible Points: 14</th>
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<tr>
<td><strong>Y</strong></td>
<td>Recycled Content</td>
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<tr>
<td>Credit 5 Regional Materials</td>
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<td>Credit 6 Rapidly Renewable Materials</td>
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<td>Credit 7 Certified Wood</td>
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<tr>
<th>Indoor Environmental Quality</th>
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<tr>
<td><strong>Y</strong></td>
<td>Minimum Indoor Air Quality Performance</td>
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<td><strong>Y</strong></td>
<td>Environmental Tobacco Smoke (ETS) Control</td>
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<td>Credit 1</td>
<td>Outdoor Air Delivery Monitoring</td>
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<td>Credit 2</td>
<td>Increased Ventilation</td>
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<tr>
<td>Credit 3.1</td>
<td>Construction IAQ Management Plan—During Construction</td>
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<tr>
<td>Credit 3.2</td>
<td>Construction IAQ Management Plan—Before Occupancy</td>
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<td>Credit 4.1</td>
<td>Low-Emitting Materials—Adhesives and Sealants</td>
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<tr>
<td>Credit 4.2</td>
<td>Low-Emitting Materials—Paints and Coatings</td>
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<tr>
<td>Credit 4.3</td>
<td>Low-Emitting Materials—Flooring Systems</td>
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<td>Credit 4.4</td>
<td>Low-Emitting Materials—Composite Wood and Agrifiber Product</td>
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<tr>
<td>Credit 5</td>
<td>Indoor Chemical and Pollutant Source Control</td>
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<tr>
<td>Credit 6.1</td>
<td>Controllability of Systems—Lighting</td>
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<tr>
<td>Credit 6.2</td>
<td>Controllability of Systems—Thermal Comfort</td>
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<td>Credit 7.1</td>
<td>Thermal Comfort—Design</td>
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<tr>
<td>Credit 7.2</td>
<td>Thermal Comfort—Verification</td>
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<tr>
<td>Credit 8.1</td>
<td>Daylight and Views—Daylight</td>
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<td>Credit 8.2</td>
<td>Daylight and Views—Views</td>
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<th>Water Efficiency</th>
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<td><strong>Y</strong></td>
<td>Water Use Reduction—20% Reduction</td>
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<tr>
<td>Credit 1</td>
<td>Water Efficient Landscaping</td>
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<td>Credit 2</td>
<td>Innovative Wastewater Technologies</td>
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<td>Credit 3</td>
<td>Water Use Reduction</td>
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<th>Energy and Atmosphere</th>
<th>Possible Points: 35</th>
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<tr>
<td><strong>Y</strong></td>
<td>Fundamental Commissioning of Building Energy Systems</td>
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<tr>
<td><strong>Y</strong></td>
<td>Minimum Energy Performance</td>
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<tr>
<td><strong>Y</strong></td>
<td>Fundamental Refrigerant Management</td>
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<tr>
<td>Credit 1</td>
<td>Optimize Energy Performance</td>
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<td>Credit 2</td>
<td>On-Site Renewable Energy</td>
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<td>Credit 3</td>
<td>Enhanced Commissioning</td>
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<tr>
<td>Credit 4</td>
<td>Enhanced Refrigerant Management</td>
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<td>Credit 5</td>
<td>Measurement and Verification</td>
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<td>Credit 6</td>
<td>Green Power</td>
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<th>Innovation and Design Process</th>
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<tr>
<td><strong>Y</strong></td>
<td>Innovation in Design: Specific Title</td>
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<td>Credit 1.2</td>
<td>Innovation in Design: Specific Title</td>
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<tr>
<td>Credit 1.3</td>
<td>Innovation in Design: Specific Title</td>
</tr>
<tr>
<td>Credit 1.4</td>
<td>Innovation in Design: Specific Title</td>
</tr>
<tr>
<td>Credit 1.5</td>
<td>Innovation in Design: Specific Title</td>
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<tr>
<td>Credit 2</td>
<td>LEED Accredited Professional</td>
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<tr>
<th>Regional Priority Credits</th>
<th>Possible Points: 4</th>
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<tbody>
<tr>
<td><strong>Y</strong></td>
<td>Regional Priority: Specific Credit</td>
</tr>
<tr>
<td>Credit 1.2</td>
<td>Regional Priority: Specific Credit</td>
</tr>
<tr>
<td>Credit 1.3</td>
<td>Regional Priority: Specific Credit</td>
</tr>
<tr>
<td>Credit 1.4</td>
<td>Regional Priority: Specific Credit</td>
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| Total | Possible Points: 110 |
LEED is not alone.
LEED is not alone.
Highway rating systems share many of the same characteristics as vertical construction ratings, but focus on highway specific issues.
Highway Rating Systems

Green LITES: New York State DOT, 2008
Green Leadership In Transportation and Environmental Sustainability

Greenroads: Washington State DOT, 2010

“Infrastructure Voluntary Evaluation Sustainability Tool”

INVEST: FHWA, 2012
Highway Rating Systems

Green Guide for Roads: Alberta

Green Pave: Ontario Ministry of Transportation

Green Guide for Roads: Transportation Association of Canada
Greenroads

Sustainability rating system for ALL roadways projects, including new, reconstruction and rehabilitation (even overlays), bridges, etc.

Project-focused: design and construction (vs. planning and operation)

Realizes we are not being sustainable yet

— just more sustainable that we used to be...

http://www.greenroads.org/
Project Requirements

Voluntary Credits 108 Points

• Environment and Water (21)
• Access and Equity (30)
• Construction Activities (14)
• Materials & Resources (23)
• Pavement Technologies (20)

Custom Credit 10 Points

Maximum Achievable: 118 Points

http://www.greenroads.org/
PR-4: Quality Control Plan

Goal

Have a process in place to monitor and improve construction quality.

Requirements

The prime contractor shall establish, implement, and maintain a formal construction Quality Control Plan (QCP). The QCP must address the following quality control elements:

1. Key quality control personnel, their responsibilities and their qualifications (résumés, certifications, etc.).
2. Procedures used to control quality during construction including (as a minimum):
   a. Items to be monitored (including pavement mix designs)
   b. Testing to be done (including testing standards and frequency)
   c. When corrective action is required (action limits)
   d. Procedures to implement corrective action
   e. Procedures to modify QCP if ineffective or when modifications are necessary

Resources

Quality Control Plan Example

Documentation

Copy of the contractor Quality Control Plan.
Strategies
Current practices for sustainable highways
Will the sustainability issues in these two places be the same?
Reclaimed Asphalt Pavements (RAP) and Recycled Concrete Aggregate (RCA) can be reused in different pavement materials to reduce the consumption of new materials.
Recycled Asphalt Shingles (RAS) are estimated to have saved 1.5 million barrels of asphalt binder between 2009 and 2010*

*Source: National Asphalt Pavement Association
Rubberized asphalt and terminal blended asphalt rubber are often used to eliminate tire waste and improve AC performance.
Glassphalt may include up to 20% by weight of recycled glass and is meant for low speed and medium volume roads*

*Source: Day and Schaffer
It is estimated by some that the term warm mix asphalt concrete will disappear in 3-5 years because all asphalt concrete mixtures will be made with these technologies.
Quiet pavements reduce societal impacts and can reduce the need for additional construction impacts from noise barriers
Service life performance must be established to evaluate true long-term effectiveness of these strategies.
Mixes developed using these non-conventional and waste materials should be carefully reviewed for potential performance impacts.
Pavement design, management, and maintenance strategies include extending long term performance through perpetual pavements and pavement preservation.
Perpetual pavements specify structural thickness and materials to resist depth specific distresses to improve the overall longevity of asphalt pavements.
Pavement preservation strategies reduce the long term economic and social impacts of highways.

Graph showing the condition of pavement over time, with original pavement lasting longer and requiring fewer major rehabilitation triggers compared to a regular maintenance approach.
Construction practices can be followed to reduce the short and long-term impacts of highway infrastructure.
Training personnel to identify environmental issues and best practice methods to minimize environmental impacts

Picture Credits to University of Washington and Greenroads Foundation; http://www.greenroads.org/
Maintain and follow a site recycling plan to reduce construction-related waste destined for landfill.
Reduce the overall consumption of fossil fuels by non-road construction equipment.
Reduce environmental impacts by utilizing dust control measures at construction site
Sustainable Construction Practices by State

<table>
<thead>
<tr>
<th>Sustainable Construction Practices</th>
<th>States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reusing waste in pavement</td>
<td>AR, <strong>AZ</strong>, IN, KS, KY, LA, MA, MI, NV, NC, OK, RI, TX, WA</td>
</tr>
<tr>
<td>Restrictions on equipment</td>
<td>IL, MD</td>
</tr>
<tr>
<td>Innovative methods to reduce energy</td>
<td>MA, WA</td>
</tr>
<tr>
<td>Improving traffic/ transportation system</td>
<td>AL, <strong>AZ</strong>, CA, CO, DC, HI, MD, MN, MO, NV, NH, OR, PA, UT, VT</td>
</tr>
<tr>
<td>Recycling / Anti-litter program</td>
<td><strong>AZ</strong>, IL, KY, MS, OK, WA</td>
</tr>
<tr>
<td>Specify requirements for sustainability</td>
<td>AK, FL, HI, ID, MO, NE, NJ, NM, OK, OR, PA, SC, SD, TN, VT, WY</td>
</tr>
<tr>
<td>Dust control</td>
<td><strong>AZ</strong></td>
</tr>
<tr>
<td>Environmental/ reducing emissions</td>
<td>CT, DE, ID, IL, IA, KS, KY, LA, ME, MT, NV, NY, NC, ND, OH, OR, PR, TX, VT, VA, WA, WI, WY</td>
</tr>
<tr>
<td>Water &amp; Storm water planning</td>
<td>ID, IL, IA, MS, NV, ND, OH, UT, WV, WI, WY</td>
</tr>
<tr>
<td>Special attention to natural habitat</td>
<td>ID, IL, IA, ME, MT, NY, ND, OH, OR, PR, WV, WY</td>
</tr>
</tbody>
</table>

Survey of DOT websites conducted in 2012 by students at Arizona State University
Wrap-up
Take away message
Key Points:

- Sustainability rating systems for highway pavements exist
- Sustainability is context-sensitive
- Developing sustainable construction practices requires local value assessment of social, economic, and ecological goals
Thank You
Asphalt Concrete Highway Construction

Pre-Construction

- Site Preparation
  - Clearing
  - Cut/Fill
  - Compaction
  - Remediation
  - Drainage

- Staging
  - Position equipment
  - Employee parking
  - Storing supplies
  - Storing equipment

- Base/Subbase Preparation
  - Hauling
  - Placement
  - QC/QA testing
  - Drainage

- Place AC Layers
  - Hauling
  - Paver transfer
  - Paver placement
  - Compaction
  - Jointing

- Stripping
  - Timing
  - Staged construction
  - Paint
  - Polymer coating
  - Glass bead placement

- Miscellaneous
  - Curb/Gutter (prior to AC placement)
  - Barriers
  - Signage

Construction

- Designate staging area and place it away from populations and environmentally sensitive areas
- Provide transit services for personnel
- Minimize overcut
- Supply erosion control
- Use cut materials as part of erosion control plan
- Use low emission equipment
- Monitor water run-off quality

- Balancing cut/fill
- Source local fill
- Store any excess cut to reduce environmental contamination
- Use low emission equipment
- Monitor water run-off quality

- Low emission equipment
- Establish onsite roller pattern

- Low emission equipment
- Use low emission equipment
- Use environmentally friendly remediation methods

- Install erosion control
- Monitor local streams for construction pollutants

- Low emission equipment
- Local plants
- Optimize timing

- Optimize timing
- Safety

- Low emission equipment
- Logistics/Planning
- Train personnel to follow best practices

- Low emission equipment
- Maintain equipment to proper weights
- Optimize compaction strategy/pattern

- Minimize number of joints
- Train personnel on best practices

Post Construction

- Minimize number of joints
- Train personnel on best practices