Concrete Pavements and Sustainability

AASHTO SOC
Environment and HR Session
San Antonio, Texas
August 7th, 2008

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Let's get one thing straight!

So-called “global warming” is just a secret ploy by wacko tree-huggers to make America energy independent, clean our air and water, improve the fuel efficiency of our vehicles, kick-start 21st-century industries, and make our cities safer and more livable.

Don't let them get away with it.

- Chip Giller
What are “green” highways?

- Environmentally and Economically Sustainable Concrete Pavements!

What is sustainability?

“Meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs”

[UN General Assembly 1987]
Green Highways Initiative

In 2005, EPA started the Green Highways Initiative as an instrument for coordinating environmentalism and transportation.

Focus on demonstrating and ensuring that sustainable practices and economic success can go hand-in-hand!

This is indeed true of concrete pavements!
What about Cement?

Although cement is a relatively energy and CO$_2$ intensive material to manufacture… cement manufacturing accounts for only 1.5% of US CO$_2$ emissions – the balance comes from…

![Pie chart showing the sources of US CO$_2$ emissions]

- **Electricity Production** (40%)
- **Transportation** (33%)
- **Other Industry** (20%)
- **Residential Heating** (6%)
What about Cement?

- Includes CO₂ emissions of cement manufacture for all concrete and masonry uses (not just pavement)...
- Concrete most widely used material on earth, apart from water ([www.wbcsd.org](http://www.wbcsd.org))
- Cement industry has lowered the amount of energy required to make a ton of cement by 33% since 1972
- CMS program pledge another 10% by 2020
What about Concrete?

- 92% of paving concrete is comprised of materials that have a low CO₂ footprint...
- All these materials are available/manufactured here in the US, often locally
- Overall sustainability benefits associated with use of concrete for pavements dramatically outweigh the impact of the cement manufacturing process...
Concrete Pavements!

- **Longevity** - hallmark of concrete pavements
- I-10 east of Los Angeles: Originally constructed in **1946** as part of US Route 66
  - Ground in 1965 (1st continuous grinding project in north America) to correct joint spalling and faulting
  - Reground for 3rd lease on life in 1984
  - In 1997 the 51 yr old PCCP was ground again
  - Today the concrete is carrying 240,000 vpd...

A true testament to concrete pavement sustainability!
Concrete Pavements!

- Not just isolated example in California...
- 50 year old pavements common in US...
- Route 23 Minnesota
  - Built 1948 (Ogilvie)
  - JPCP, 9”, doweled
  - PSR 4.1 (very good)
  - > 50%, >50yr are >3.1
Concrete Pavements!

- Belknap Place, San Antonio
- Constructed in 1914
- Laid in two-courses
- Stamped (traction)
- Serving today!
- Similar sustainable examples in:
  - NY, IA, SC, WA…
Longevity means...

- Less-frequent reconstruction
  - Lower consumption of raw materials
    - Cement, aggregates, steel
  - Lower energy consumption
    - Raw material processing
    - Rehab and reconstruction
    - Congestion
Longevity means... (cont.)

- Reduction in pollutants
  - Manufacturing, construction, congestion
- Lives saved
  - Rigid structure, profile durability
  - Infrequent construction zones
- All these translate into real economic benefits...

Longevity is a crucial element of sustainability!
Sustainable Benefits *Beyond* Longevity

- Improved Fuel Economy
- Lower Energy Footprint
- Light Colored and Cool
- Less Fuel Consumed During Construction
- Industrial By-Product Use
- Improved Stormwater Quality
- Renewal and Recycling
- New Quiet Surface Textures
Improved Fuel Economy

- Rigid Surface
  - Lower Deflection
  - Less Loss

- In-depth study by NRC Canada and NRCan
- Significant fuel consumption reductions for trucks on concrete pavement (0.8-6.9%)
- Average savings per truck (100,000mi, 5.5mi/G, $4.33/Gal)
  - $3,030
  - 8.1 ton CO₂
  - 183 lb NOx
  - 22 lb SO₂

- Huge environmental and cost savings...
Improved Fuel Economy: Example

62 mile long arterial highway; 20,000 vpd; 15% trucks; 5.5mpg; 30yr design life…

- An average of **165,000 tons CO₂** saved
- Greater than **three times** as much CO₂ as emitted during cement manufacture!
- CO₂ associated with concrete pavement is compensated for during the **first 9 years**
Lower Fuel Consumption during Construction

- Construction of HMA roadways consumes $5\frac{1}{2}$ times as much fuel (diesel) as construction of concrete roadways.
Lower Fuel Consumption during Construction

- FHWA estimates that 500 million tons of HMA placed annually.
- If concrete roadways were placed instead for just ½ of this amount of asphalt, it would amount to annual fuel savings greater than 1/2 billion gallons!!!
- Savings are staggering - CO₂ equivalent to taking 1.4 million cars off the road!
Concrete is a huge consumer of industrial by products ~ 25% FA, 50% SC, ternary, blends

Over 15,000,000 tons FA used in concrete in US annually, ↑ (ACAA 2006)

Reduces disposal, lowers cement intensity (with its CO$_2$) and improves both performance and longevity!

Slag aggregates…
Renew-ability, Recycling and Reuse

- Renewal through grinding
  - CalTrans study suggest an additional 17 years service life gained
  - Design for multiple grind activities…
  - Minimal use of energy and natural resources
Renew-ability, Recycling and Reuse

- What is the most recycled material in United States?

- CONCRETE, according to Construction Materials Recycling Association

- Concrete is 100% recyclable: new concrete, subbases and granular fill

- On-site…
Renew-ability, Recycling and Reuse

- Carbon sequestering:
  - 60% of the CO$_2$ emitted during cement production is due to calcination.
  - Once cement has hydrated the reaction can start occurring in reverse – carbonation.
  - Recycling and crushing accelerates this dramatically - can allow the recapture of all CO$_2$ evolved during calcination (RMRC ‘05).

- 53 million tires used in cement kilns (EPA ‘03)
Light Colored and Cool

Enhanced Nighttime Visibility:
- Improved pedestrian and vehicle safety
- Reduced lighting and energy requirement:
  - Fewer fixtures or lower wattage fixtures
  - Up to 1/3 energy savings!
Urban Heat Island Mitigation:

Urban areas up to 9°F warmer due to UHI

Greater energy use and resulting pollution

PCC is an effective mitigation strategy

Lower city temperatures

Lower cooling costs

Reduce smog formation

Potential energy savings

$5B in US alone

(ALB'05)

HMA (painted)

AR-OGFC

Chip Seal

HMA

HMA (painted)

AR-OGFC (painted)

CR-PCC

AR-OGFC (painted)

HMA (painted)

PCC

PCC

thickness = 30cm (12in)
Lower Energy Footprint

- Embodied primary energy is a measure of all energy use associated with the production, delivery and maintenance of a facility over a specific period.
- Includes both feedstock and primary energies.
- ASMI analyzed total embodied primary energy for various equivalent concrete & asphalt pavement structures for several different road types in various geographic regions over a period of 50 years.

(Athena ’06)
Lower Energy Footprint

- Considers:
  - Extracting
  - Processing
  - Production
  - Construction
  - Maintenance
  - Rehabilitation

- Concrete lower for all classes analyzed!
- **23% lower** for urban freeways
- **71% lower** if feedstock energy is considered!
Improved Water Quality

Use of Pervious Concrete Pavements:
- Reduce storm water runoff
- Capture/treat pollutants
- Recharge groundwater
- Evaporative cooling
- Reduce noise pollution
- Ongoing EPA/Industry studies
New Quiet Surface Textures

- Create any desired surface texture…
- FHWA TA 5040.36 on Surface Texture (*FHWA ’05*)
- Research by FHWA, NCPTC, ACPA, Purdue, etc.
  - Optimize friction/vehicle control
  - Minimize noise pollution
- NGCS – quietest PCCP texture measured (2007)
- Surface texture/profile durability!
Concrete pavement is the sustainable choice!

- Lower overall energy footprint!
  - Long lasting and renewable
  - Less fuel and CO$_2$ to construct
  - Less resource intensive
- Better fuel economy – less CO$_2$, NOx and SOx
- Use of industrial by-products, recycle, recapture
- Urban Heat Island mitigation, better visibility
- New quiet and permeable textures
In Conclusion...

- US concrete paving industry strongly supports sustainable development.
- These factors not often considered when making pavement choices... they should.
- **Environmental** and **social** sustainability can and does go hand-in-hand with **economic** efficiency!
- This is a real opportunity for all of us.
Resources...

• ACPA published a Special Report on Green Highways
• Released in October 2007
• Available on our website at: www.pavement.com

Topics for our 2008 program:
• Concrete Mix Design Basics
• Concrete Pavement Materials
• PCCP Sustainability
• Curing
• Hydration Processes
• Introduction to the M-E PDG
• Joint Layout and Design
• Life Cycle Cost Basics
• Materials Incompatibility
• Maturity
• Slipform Paving Operations
• Soil Stabilization
• Texturing Concrete Pavements
• Thickness Design – Municipal
• Troubleshooting Slabs on Grade

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CONCRETE PAVEMENT 101/201
Questions?
Questions?

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