Sustainability and Pavements: Are We Focusing On the Right Things?

Tomorrow’s High Performance Concrete Pavements Today
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ACPA National: Who are we?

A Unified Voice for the Concrete Pavement Industry!

- Recent Refocusing Effort
- National Core Mission
- Efficient and Effective Delivery of Strategic Goals with Partners
  - Chapters
  - Agencies
  - Cement Industry
  - CPTech Center
ACPA: Re-Focused and Fine-Tuned

A Unified Voice for the Concrete Pavement Industry!

- Advocating for Infrastructure Investment in Washington
- Providing GUIDANCE for concrete pavement
- Developing TOOLS for the betterment of the concrete pavement industry (apps.acpa.org)
- Delivering TRAINING and certification programs
- Guide RESEARCH and deployment

THANK YOU for your support!
Talking Points

- Sustainability – What do we mean?
- In the Context of Pavements?
- What are we focusing on today?
- What should we be focusing on?
  - Life Cycle Assessment
  - The Use Phase...
- Parting Thoughts
Sustainability and Pavements: Are we Focusing on the Right Things?

SUSTAINABILITY?
What is Sustainability?

- **Sustainability** – derived from Latin: *sustinēre* (from *sus*, up and *tenēre*, to hold)

  Essentially the capacity to **endure**.

- Term applied very broadly to every facet of life, but increasingly in the context of human sustainability on Earth – particularly as causes of global warming and climate change are debated.
Sustainability?

- Highway Engineer will focus on
  - Structural design
  - Pavement materials
  - Construction
- Items such as:
  - Recycling
  - Industrial byproducts
  - Resource conservation
  - Energy use

Are we missing significant opportunities?

Are we missing the target?
Sustainability?

YES!

- Opportunities are missed by ignoring the operational or use-phase of the pavement!
- Research suggests the long-term, cumulative benefits are staggering [*Europe, North America*]
- Mostly relates to fuel use and surface reflectivity
- So, central question for engineers/administrators: In the context of sustainable practices... *Are we focusing on the right things?*
Sustainability and Roadways?

Fundamentally, how do we balance

Natural environment,

Societal needs,

Economic vitality,

when talking about pavements?

Lots of research, lots has been written... but, significant confusion remains!
Sustainability and Roadways?

- ACPA Special Report on Green Roadways...
  - Emphasizes longevity as the primary opportunity!!

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**Green Roadways**

*Environmentally and Economically Sustainable Concrete Pavements*

**Introduction**

The concepts of "sustainability" and "sustainable development" are receiving considerable attention in the context of global warming and climate change issues. The World Commission on Environment and Development has defined sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." (WCED 1987).

In recent years, it has been suggested that to ensure the long-term viability of green pavement systems, we need to consider the impact on our natural resources and environment. This concept is often referred to as the "triple bottom line" or the "triple bottom line." A major focus of this report involves ensuring that sustainable practices in pavement design, installation, and maintenance are used and maintained.

This report is a step toward understanding the benefits of using concrete pavements for sustainable transportation purposes.

**Contents**

- Introduction
- Longevity
- Economic Benefits
- Environmental Benefits
- Life-Cycle Analysis
- Cost-Effective Pavement
- Conclusion

**Countless examples worldwide!**
Sustainable Benefits *Beyond* Longevity

*Can be achieved through selection design and mixture optimization!*

- Reduced Fuel Consumption (During Construction & Use)
- Light Colored and *Cool*
- Pavement Recycling
- Industrial Byproduct Use
- Improved Stormwater Quality (Pervious Concrete Shoulders)
- Quiet Surface Texture
- Resource Efficiency
- Lower Energy Footprint
- Surface Renewal (Diamond Grinding)
Sustainability and Roadways…

What to make of all these opportunities?

- *Cradle-to-grave* or *end-to-end* analysis has emerged…
- Life Cycle Assessment (LCA) (*not LCCA*)
  - ISO 14040 series of standards
- Involves a “*cumulative analysis of impacts throughout all stages of the life cycle*”
Sustainability and Roadways...

**LCA concept [EPA 2006]**

Captures "use-phase" (traffic impact etc.)
Sustainability and Roadways...

Only via this kind of comprehensive Life Cycle Assessment will highway administrators be able to consider and properly account for the cumulative impacts of their decisions!
Sustainability and Pavements: Are we Focusing on the Right Things?

What are we doing?
What are we currently focusing on?

Material Production & Construction!
- Recycled materials (RCA, RAP, rubber, shingles)
- Industrial by-products (slag, flyash...)
- Energy use and emissions (new cements, warm-mix)
What are we currently focusing on?

- Sustainability programs and rating systems have emerged for pavements.
  - GreenRoads (rate roadways, not an LCA)
  - FHWA Self Evaluation Tool (rating)
  - FHWA Sustainable Pavements TWG
  - ISI Envision (rating)

- Relate to production/construction phases
- Little is focused on the long-term use or operational phase of its life-cycle!
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What should we be doing?
What should we be doing?

Clarification:

*All the commonly adopted sustainability strategies are important and should be embraced!*

...though, it is useful to know where we can be most impactful.

Recent comprehensive LCA studies are giving us clues as to where that is...
What should we be doing?

[Centre d’Energetique de l’Ecole des Mines de Paris]

Ecoprofile of different life cycle stages of a typical road.
What should we be doing?

From this LCA we see:

- Overall impacts from use-phase dwarfs impacts from ALL other phases of the roadway life cycle
- From energy perspective... construction and maintenance accounts for less than 2% of the entire energy footprint [EAPA 2004]

Therefore (as an example):

- Just a 2-3% improvement in the truck/car portion of the ecoprofile could offset the entire construction and maintenance ecoprofile!
What should we be doing?

[Centre d’Energetique de l’Ecole des Mines de Paris]

Ecoprofile of different life cycle stages of a typical road.
What should we be doing?

“ECOPROFILE”

USE PHASE

Extraction, Production, Construction

End of Life

Where do our “conventional” sustainability tools fit in this ecoprofile?

RCA, RAP, Flyash, Slag, Warm Mix?
What should we be doing?

“ECOPROFILE”

**USE PHASE**

Extraction, Production, Construction

End of Life

SO... if we make a **30%** improvement in the production energy footprint (Warm Mix)...

...that small sliver would be the impact on the entire life-cycle “ecoprofile”!
What should we be doing?

“ECOPROFILE”

USE PHASE
Extraction, Production, Construction

End of Life

However, what if we can find a way to reduce the use-phase portion by, say 5%?

This yellow area would represent the overall impact...
What should we be doing?

What are these use/operational-phase impacts?

- **Vehicle fuel consumption rates**
  - Pavement rigidity
  - Pavement smoothness

- **Pavement surface reflectivity (albedo)**
  - Urban heat island mitigation
  - Lighting need
  - Global cooling potential

**CoolMix!**
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Vehicle Fuel Economy
Vehicle Fuel Economy

- Rigid Surface → Lower Deflection → Less Loss

- In-depth study by National Research Council Canada

- Significant fuel consumption reductions for trucks on concrete pavement (0.8-6.9%)

- Sweden, UTA, NCHRP, MIT
Vehicle Fuel Economy: Rigidity

- **US DOT data**
  - **US truck fuel consumption**
    - ≈ 39 billion gallons per year
  - With just a 3% improvement on roughly 70% of the network, savings would amount to...
  - ...approx **820 million gallons of diesel/yr**
    - (19 billion lbs CO₂ eq. and $3 billion)
  - Additional savings from lighter vans, cars, etc.
Improved Fuel Economy: Smoothness

- Smoothness – smooth roads are fuel efficient roads.
  - Should specify and construct smooth concrete pavements
  - FHWA reported a 4.5% improvement in fuel economy (trucks) with smoothness (IRI) improving from 152in/mile to 76in/mile ('00).
  - Ongoing work as well at MIT and NCHRP.
  - Applies not just to new pavements – must maintain smoothness. Pavement renewal!
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Surface Reflectivity
Surface Reflectivity - Lighting

Enhanced Nighttime Visibility:

- Improved pedestrian and vehicle safety
- Reduced lighting & energy requirement:
  - Fewer fixtures/watts
  - Up to 33% reduction
  - AASHTO - 40% lower
  - Huge budget impact!
Surface Reflectivity – Urban Heat

Urban Heat Island Mitigation:
- Urban areas up to 9°F warmer due to UHI
- greater energy use and resulting pollution
- PCCP is an effective mitigation strategy
  - lower city temperatures
  - lower cooling costs
  - reduce smog formation
- Pot. energy savings
  - $2B in US alone (LBNL’08)
Surface Reflectivity – Global Cooling

5th CA Climate Change Conf (LBNL and CEC)

Strategies

- Cooler Roofs
- Shade Trees
- Cooler Pavements
- All Vegetation

Processes

- Reduces A/C Use
- Reduces Demand at Power Plants
- Area Sources Emit Less
- Slows Reaction Rates

Results

- Less Energy Consumed
- Lower CO₂, NOₓ, and VOC Levels
- Lower Ozone Levels
Surface Reflectivity – Global Cooling

- Concept is that earth is not a closed system.
- Reflective materials on earth’s surface (snow, ice, concrete) return more of sun’s energy back into space – reducing temperatures.
- This amounts to the equivalent of CO$_2$ reduction (offset).
Global Cooling

- Cities 1% of global land area
- 60% cities=roofs/pavements
- Cool roofs and pavements (concrete) can increase urban albedo by 0.1, and in turn induce negative radiative forcing.

If implemented in 100 largest cities in world, this can offset 44Gt of emitted CO$_2$ ($1.1$ trillion at $25$/ton) – proposal to UN considered.
Early Experiments in Transportation

Sustainability and Pavements

Parting Thoughts
Parting Thoughts

- Lots of sustainability opportunities with concrete pavement construction – opt for longevity!
  - Recycling, SCM's, Pervious, Optimized Design…

- Industry committed to sustainable approaches in all aspects of pavement construction

- **But**, we may be missing enormous opportunities by focusing solely on the production and construction aspects (less than 5% of footprint)

- Must consider the use-phase (dwarfs all else)!!!
Parting Thoughts

- The use-phase has an enormous impact!

Long service life - exposed every hour of every day, supporting millions of cars/trucks

- Vehicle fuel consumption (rigid and smooth)
- Surface reflectivity (light, UHI, global cooling)

- Not much different than the challenge with project costs and LCCA...
Great thing is that we can control what we consider – focus on the right things!

From what we know today, **rigid**, **smooth** and **light-reflective** pavement surfaces will be a major focus of sustainable roadway practices moving forward (i.e. coolmix pavements).

Focusing on the things that actually matter will better enable us to sustain our experience here on earth – i.e. to **endure**!
Resources...

Recently published
Special Report →

Available at:
www.acpa.org

Much work ongoing:

Massachusetts Institute of Technology
CONCRETE SUSTAINIBILITY HUB