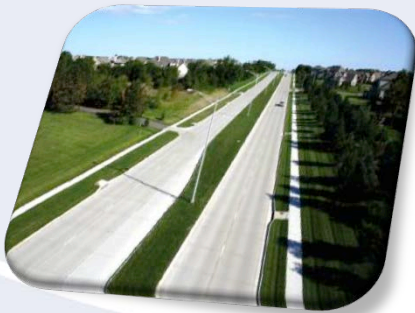


Sustainability and Pavements: Are We Focusing on the Right Things?



Betonwegendag 2011

'Beton goed op weg'

's-Hertogenbosch

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American Concrete Pavement Association

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



[VanDam 2009]

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!!



- Countless examples worldwide!

Sustainability and Roadways!

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!

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.)

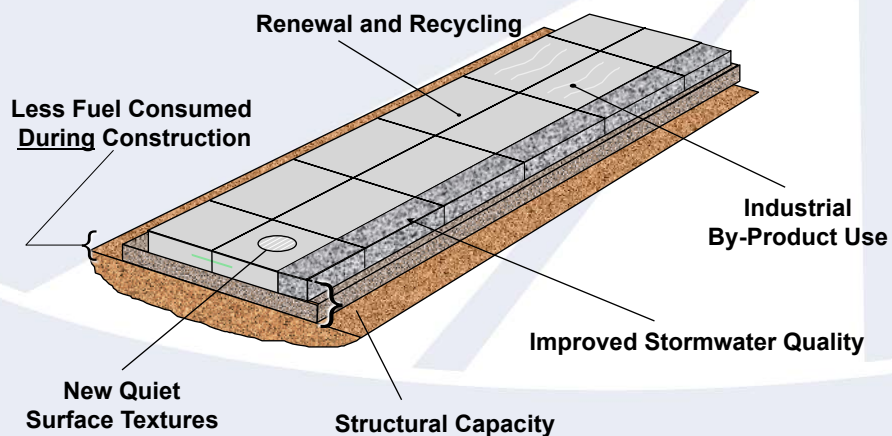
- Reduction in pollutants
 - Manufacturing, construction, congestion
- Lives saved
 - Rigid structure
 - Profile durability
 - Infrequent construction zones
- All these translate into economic benefits...



Longevity is a crucial element of sustainability!

Sustainable Benefits *Beyond* Longevity

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



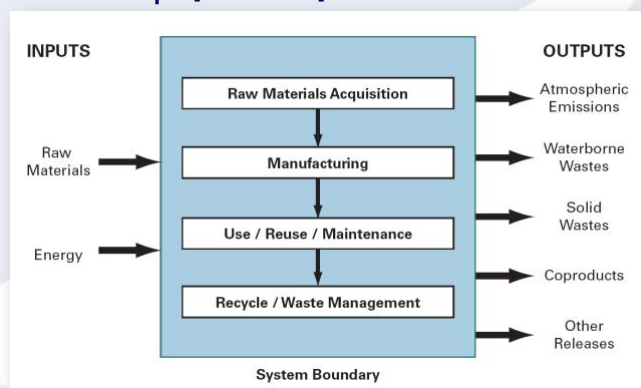
Sustainability and Roadways...

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...)



[Image PCA]

- Energy use and emissions (new cements, warm-mix)

[Image Oldcastle]



What are we currently focusing on?

- Sustainability programs and rating systems have emerged for pavements.
 - Green Highways Partnership (encourage)
 - GreenRoads (rate roadways, not an LCA)
 - FHWA Self Evaluation Tool (rating)
- Relate to production/construction phases
- Little is focused on the long-term use or operational phase of its life-cycle!



Sustainability and Pavements: Are we Focusing on the Right Things?

What should we be doing?

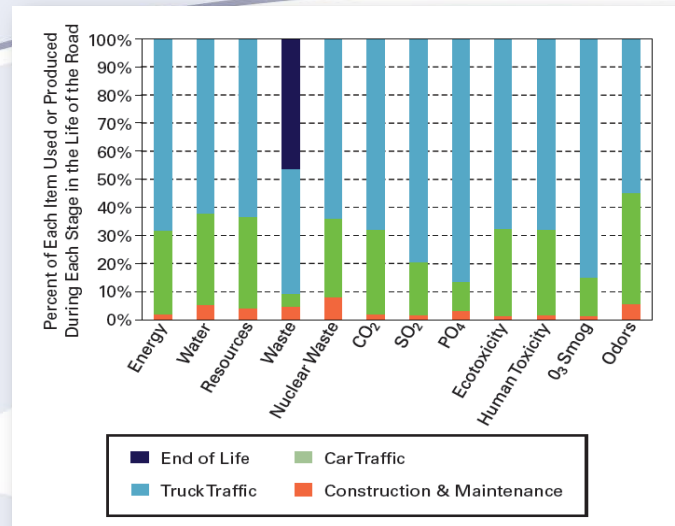
What should we be doing?

- **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?



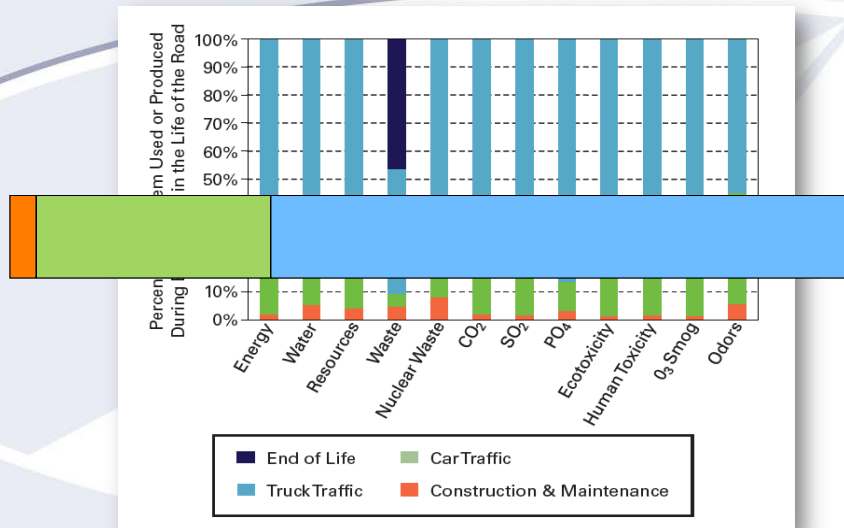
[Centre d'Énergie de l'École des Mines de Paris]

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?

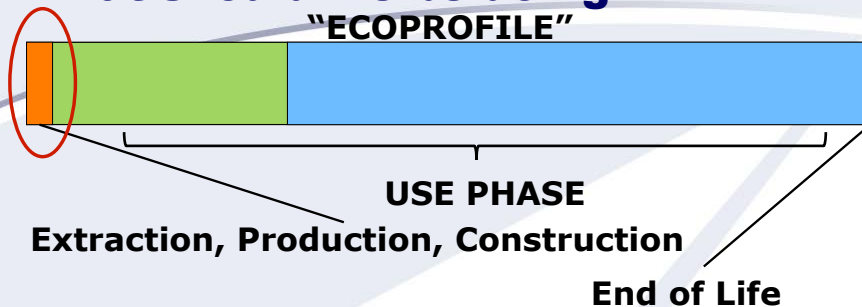


[Centre d'Énergie de l'École des Mines de Paris]

Ecoprofile of different life cycle stages of a typical road.

What should we be doing?

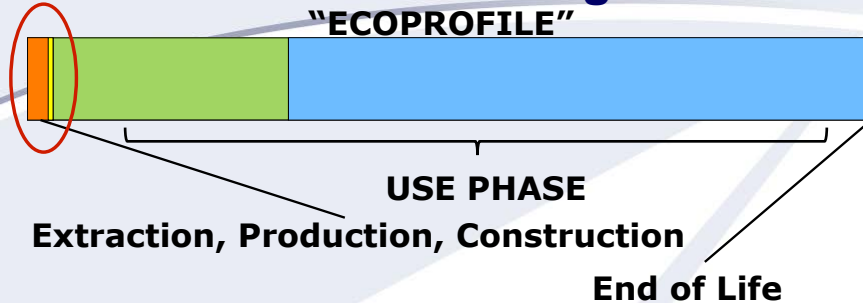
"ECOPROFILE"



Where do our "conventional" sustainability tools fit in this ecoprofile?

RCA, RAP, Flyash, Slag, Warm Mix?

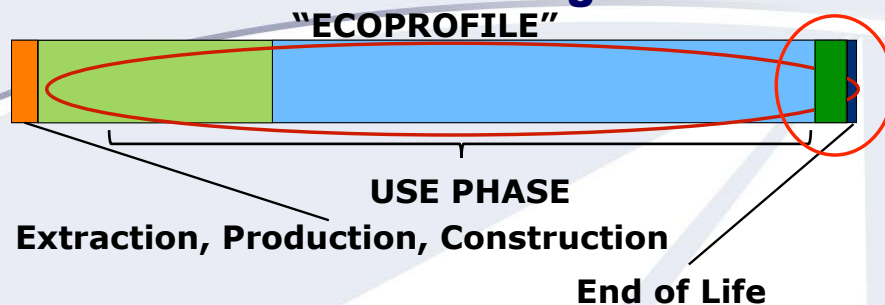
What should we be doing?



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?



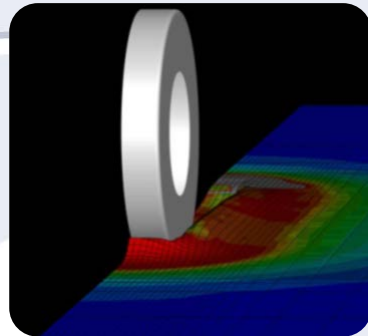
However, what if we can find a way to reduce the use-phase portion by, say **5%**?

This green 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

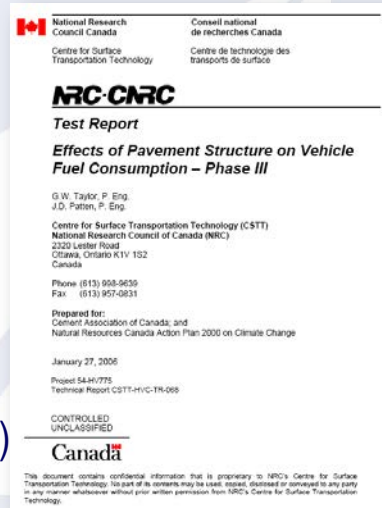


Sustainability and Pavements: Are we Focusing on the Right Things?

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%**)
- Other studies support this...



Vehicle Fuel Economy: Rigidity

- US DOT data
 - US truck fuel consumption
148 billion liters per year
 - With just a 3% improvement on roughly 70% of the network, savings would amount to...
... approx **3.1 billion liters of diesel/yr**
(8.6 billion kg CO₂ eq. ~ \$3 billion)
 - Additional savings from lighter trucks, 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 2.4m/km to 1.2m/km ('00).
 - Ongoing research as well.. (NCHRP, MIT)
 - Applies not just to new pavements – must maintain smoothness. Pavement renewal!



Sustainability and Pavements: Are we Focusing on the Right Things?

Surface Reflectivity

Surface Reflectivity - Lighting

Enhanced Nighttime Visibility:

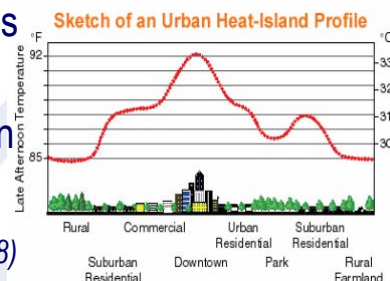
- Improved pedestrian and vehicle safety
- Reduced lighting & energy requirement:
 - Fewer fixtures/watts
 - Up to 33% reduction
 - AASHTO - 40% lower
 - Huge budget impact!



Surface Reflectivity – Urban Heat

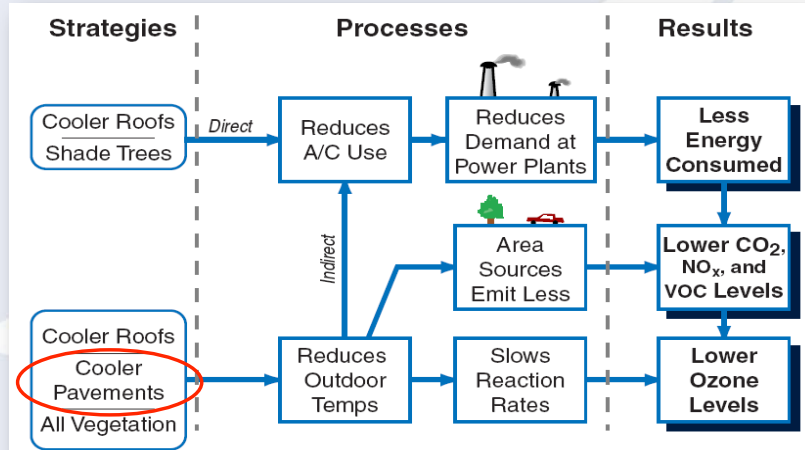
Urban Heat Island Mitigation:

- Urban areas up to 9° 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)



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 CO₂ 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 **44Gton** of emitted CO₂ (\$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 for decades, 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...



Parting Thoughts

- 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.
- 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:

National Concrete Pavement
Technology Center



Massachusetts Institute of Technology
CONCRETE SUSTAINABILITY HUB



Thank You!

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