Concrete Pavements and Sustainability

Portland Cement Concrete Pavement Conference

Macon, Georgia

October 14, 2008

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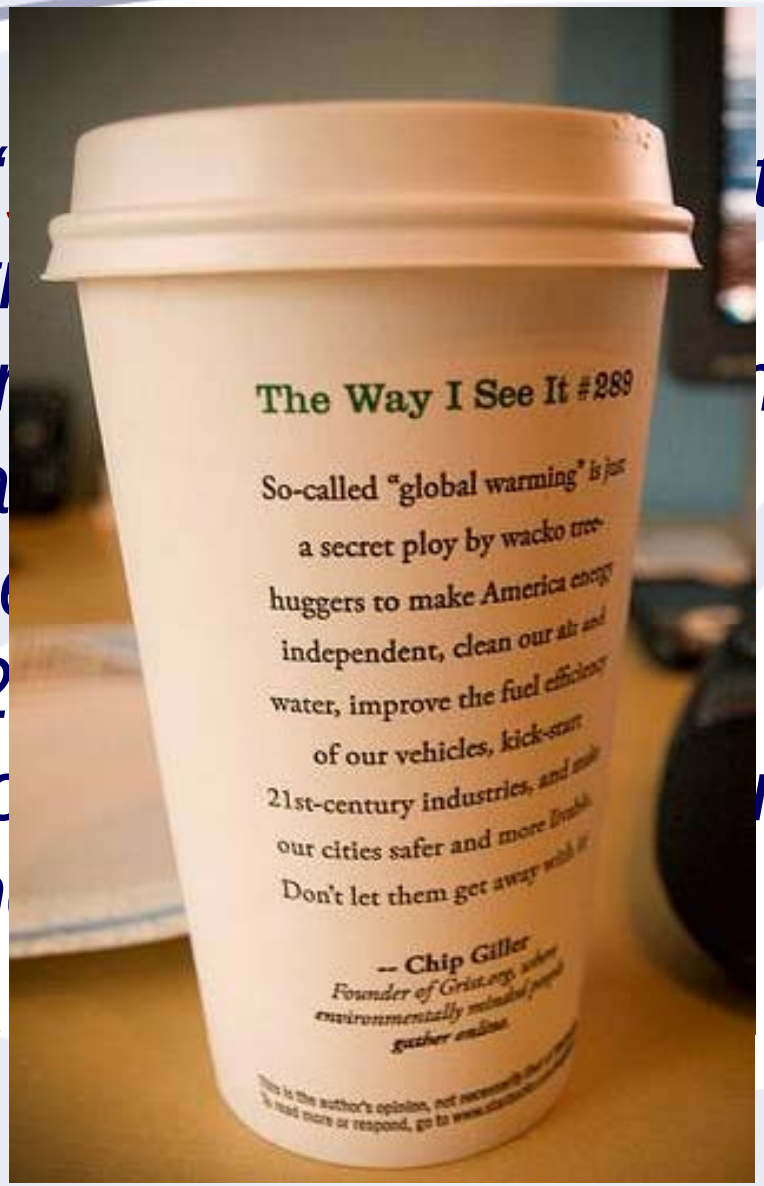
Director of Highways

Lets get one thing straight!

- *So-called "t a secret ploy by wacko t make Amer nt, clean our a improve th vehicles, kick-start 2 and make c re livable. Don't let th*

- Chip Giller



Learning Objectives

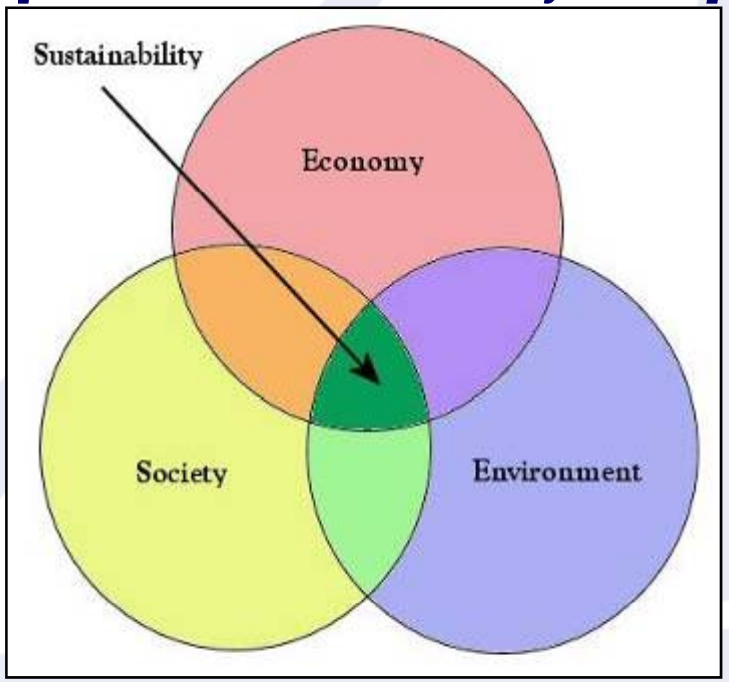
- What is sustainability?
- What about cement?
- What about concrete?
- Longevity and sustainability.
- Other sustainability benefits.
- Conclusions.

Concrete Pavements and Sustainability

SUSTAINABILITY?

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]*
- Triple bottom line:
  - Environmental
  - Social
  - Economic

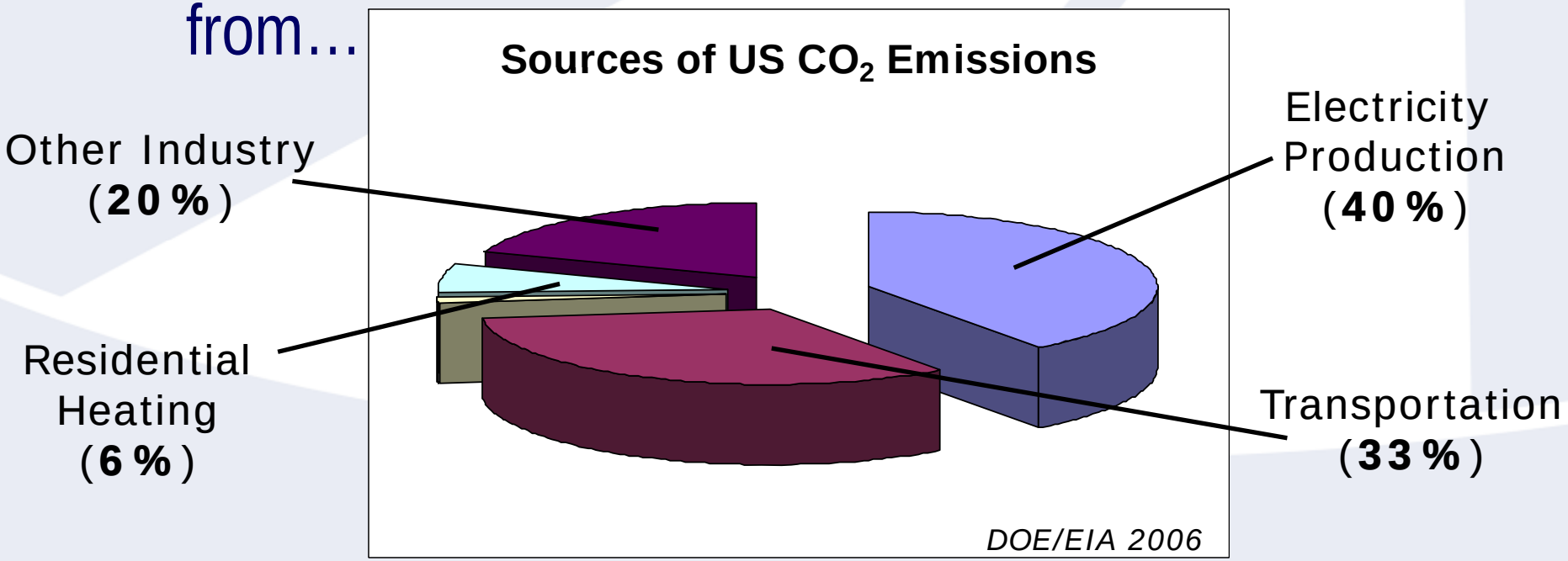


Green Highways Initiative

- 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 man-made CO_2 – the balance comes from…

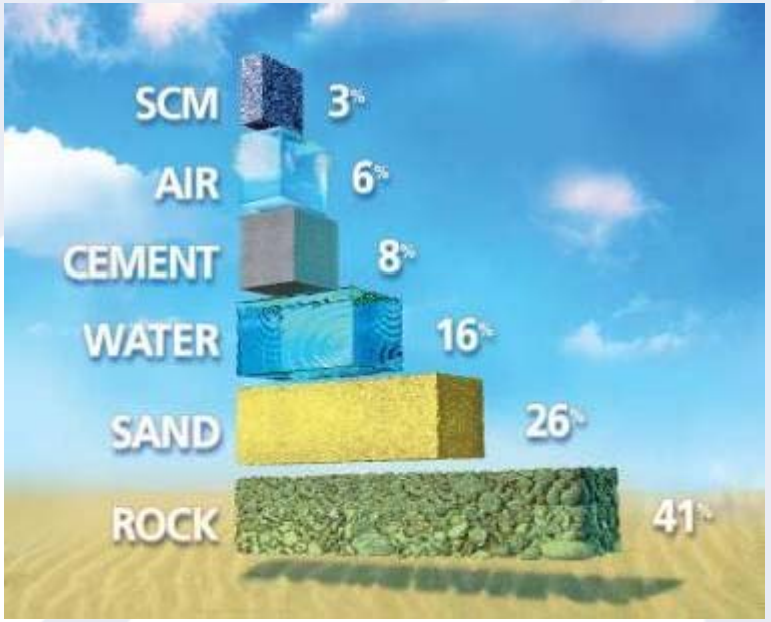


What about Cement?

- Includes CO_2 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)*
- 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 CO_2 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 and Sustainability

LONGEVITY

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

Note: PSR = Present Serviceability Rating

Concrete Pavements!

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

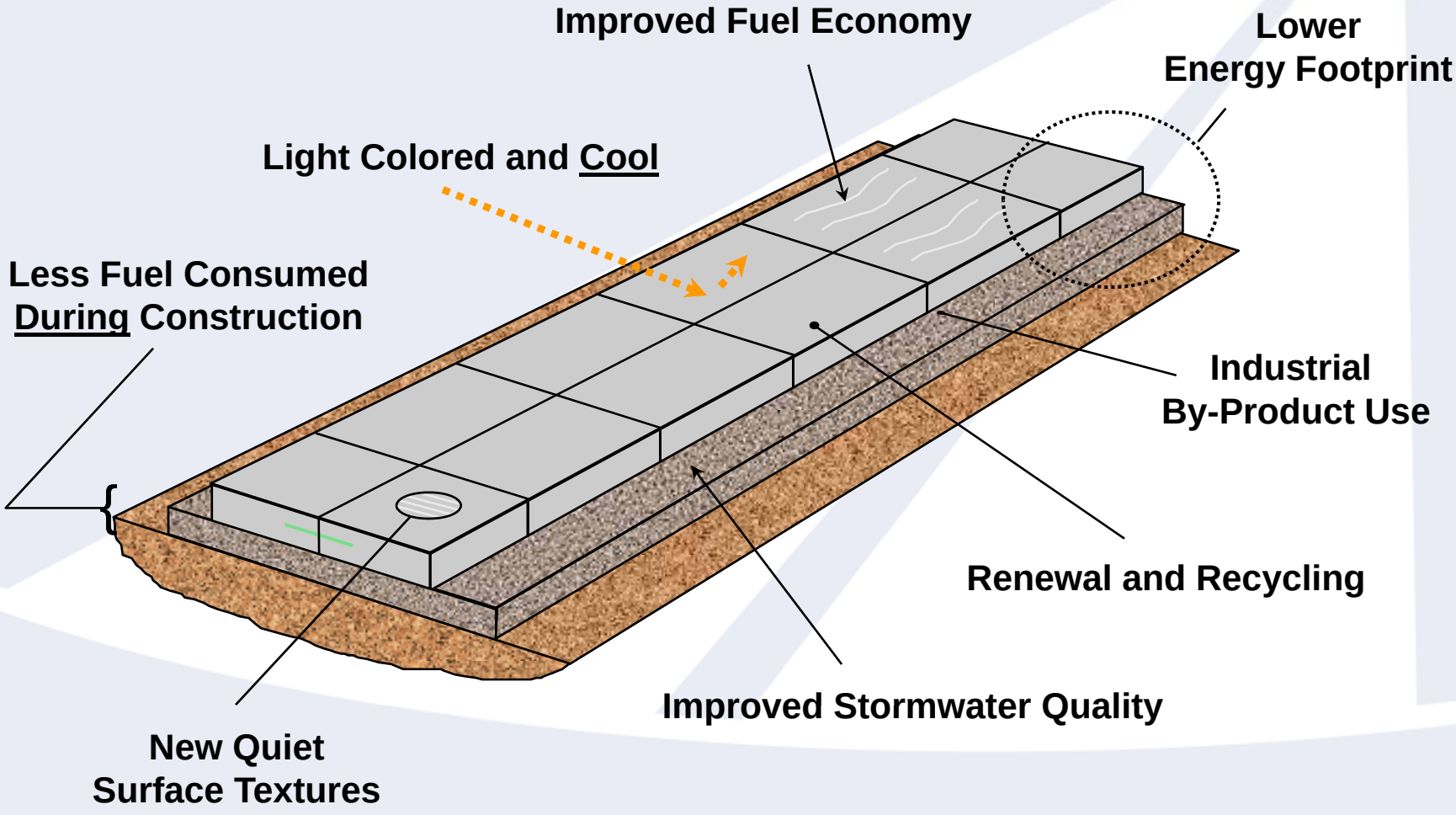
Longevity is a crucial element of sustainability!

Concrete Pavements and Sustainability

OTHER BENEFITS

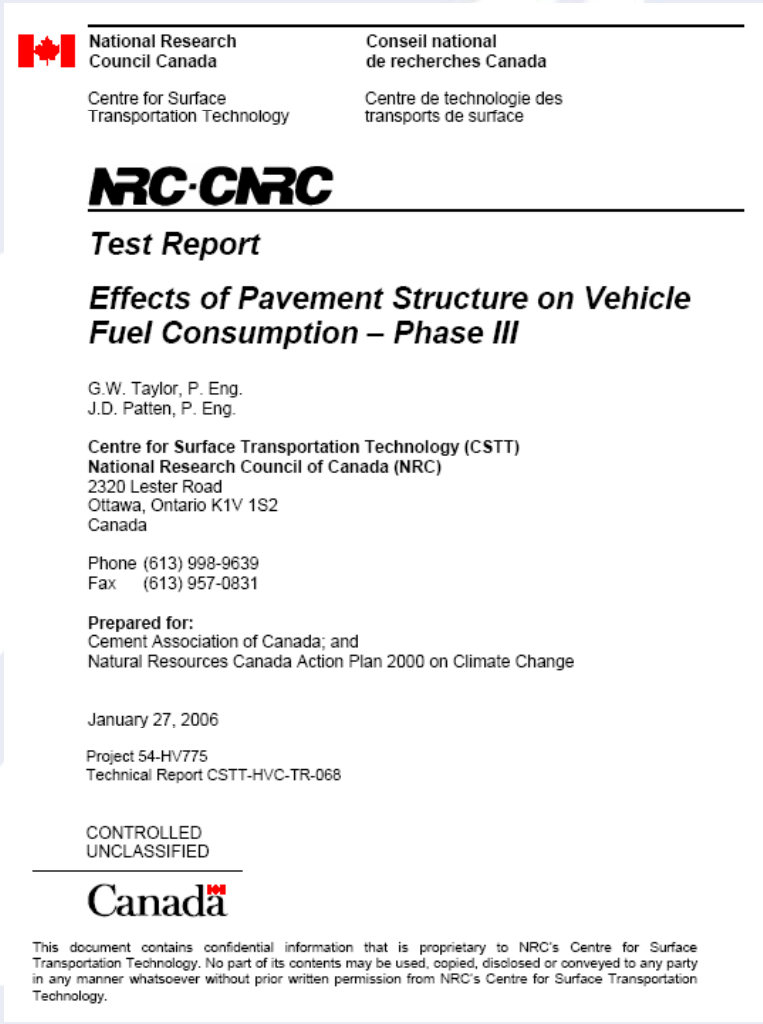
Sustainable Benefits *Beyond* Longevity

Can be achieved through design and mixture optimization!



Improved 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%)
- Caltrans, Sweden



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Test Report

Effects of Pavement Structure on Vehicle Fuel Consumption – Phase III

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Improved Fuel Economy

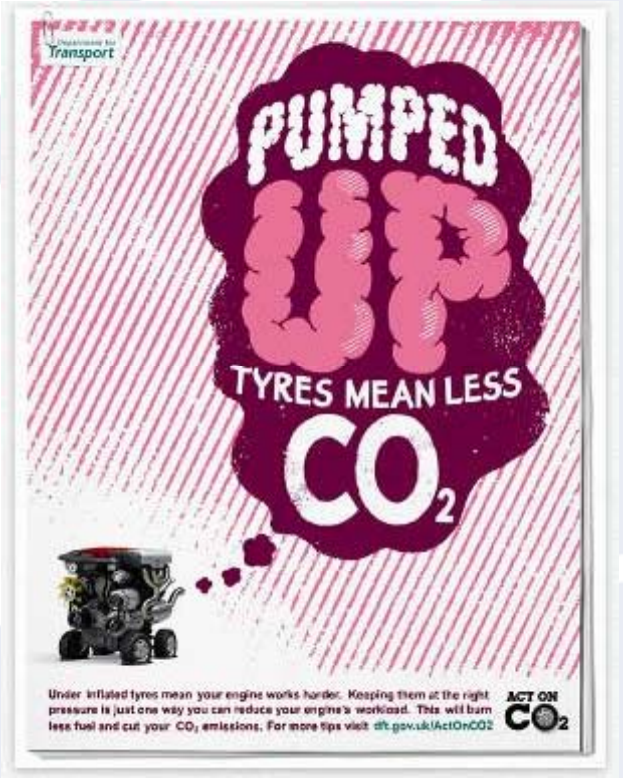
- Yearly savings **per truck** (100,000mi, 5.5mi/G, $4.33/Gal)

  $3,030 – 8.1ton CO_2 – 183lb NOx – 22lb SO_2
- Huge environmental and cost savings…
- In 2002 there were 2.6 million heavy trucks in US alone *(USDOT RITA 2008)*
  - $7.9 billion potential savings
  - 21 million tons CO_2

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 CO_2** saved
- Greater than **three times** as much CO_2 as emitted during cement manufacture!
- CO_2 associated with concrete pavement is compensated for during the **first 9 years**



Concrete Pavements and Sustainability

Lower Fuel Consumption During Construction

Lower Fuel Consumption During Construction

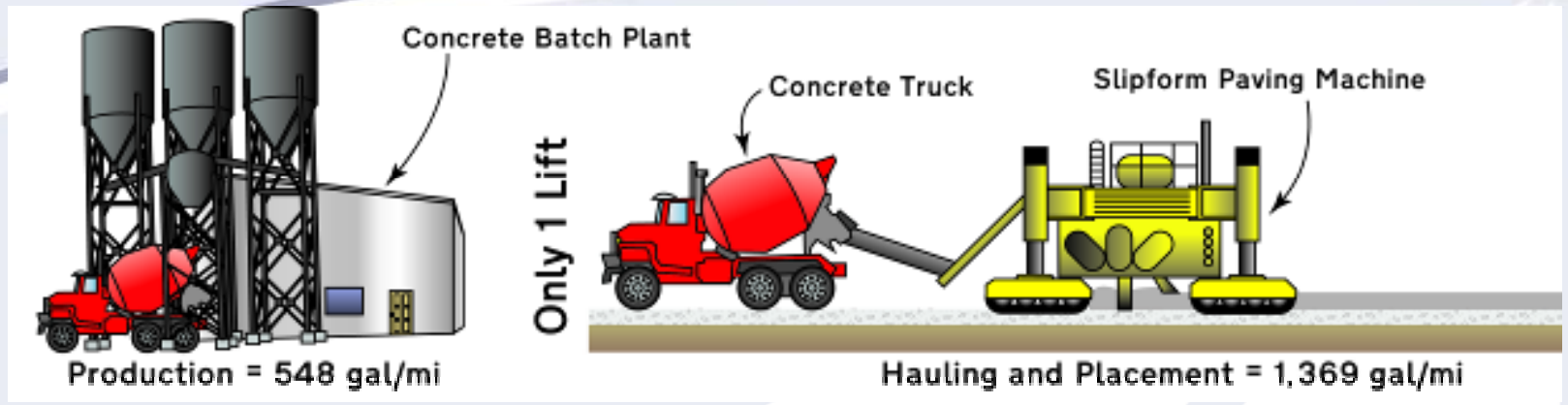
- FHWA TA T5080.3 on *Price Adjustment Contract Provisions* give Fuel Usage Factors *(FHWA 1980)*
  - Construction of HMA roadways consumes **5½ times** as much fuel (diesel) as construction of concrete roadways

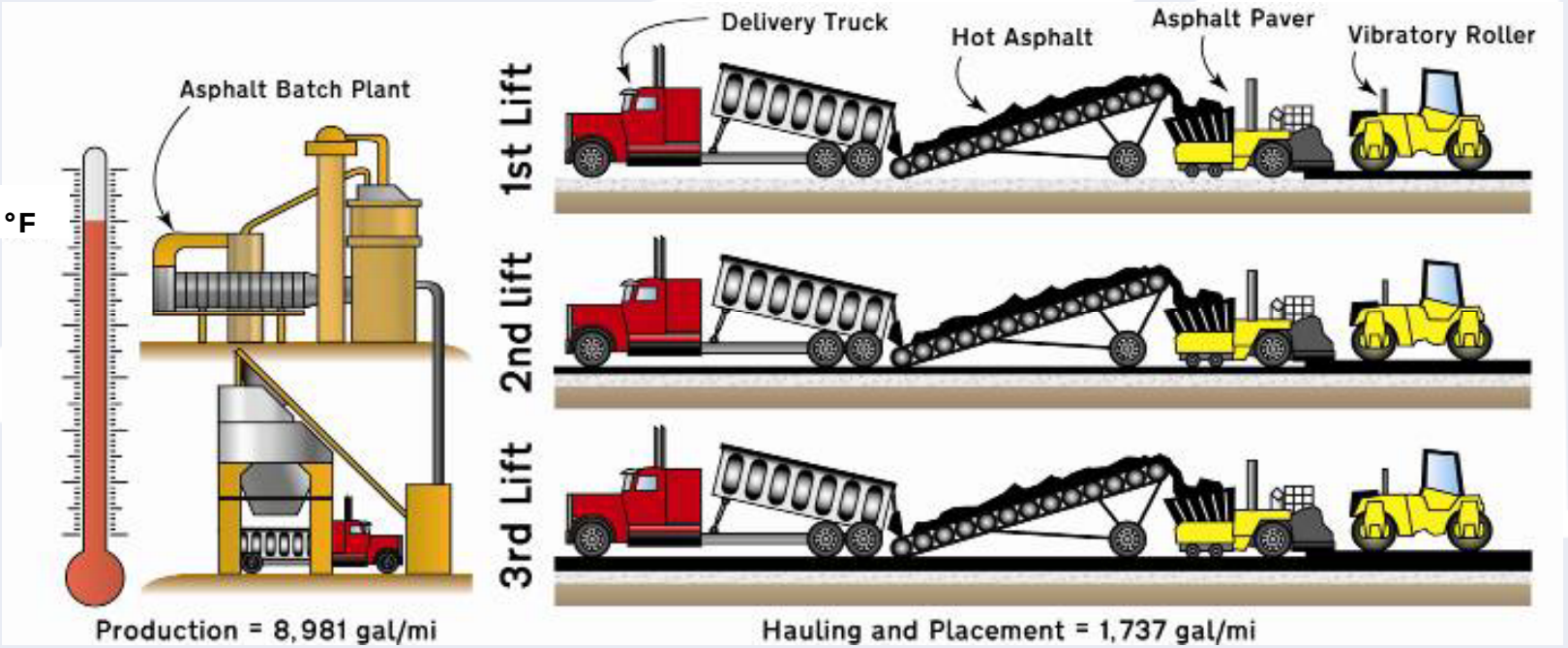
Diesel Fuel Used During Construction
(Gallons/Mile)

Asphalt Pavement	Low	Avg.	High
Production	6,468	**8,981**	12,936
Hauling (0-10 miles)	1,035	**1,220**	1,257
Placing (3 layers required)	222	**517**	739
Asphalt Total:	7,725	**10,718**	14,932

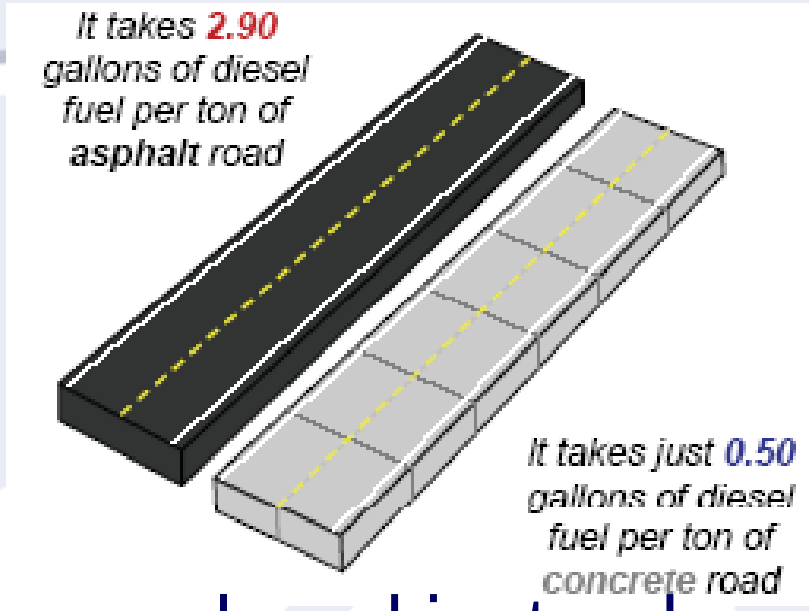
Concrete Pavement	Low	Avg.	High
Production	293	**548**	880
Hauling (0-10 miles)	645	**939**	1,310
Placing (1 layer required)	254	**430**	606
Concrete Total:	1,193	**1,916**	2,796

Lower Fuel Consumption During Construction





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 - CO_2 equivalent to taking 1.4 million cars off the road!

Concrete Pavements and Sustainability

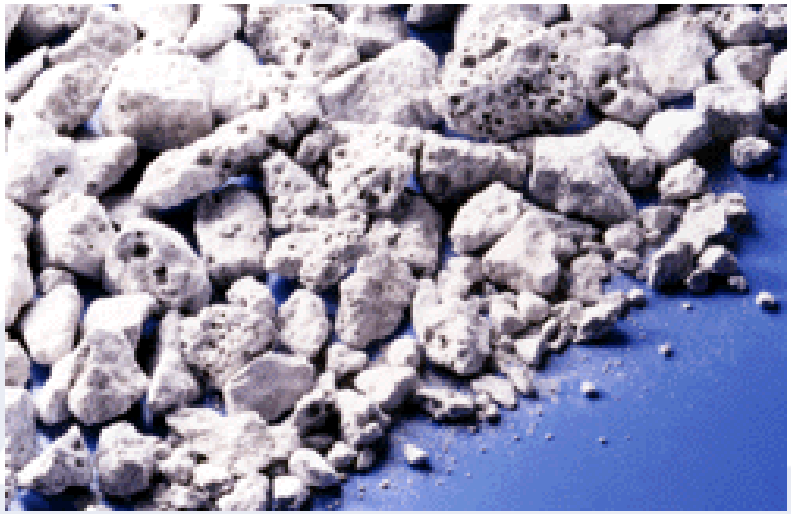
Use of Industrial By-Products

Use of Industrial By-Products

- Concrete is a huge consumer of industrial by-products
  - Up to 25% fly ash (from burning coal)
  - Up to 50% slag cement (from iron smelting of ore)
  - Others, ternary mixtures, and blended cements
- Opportunities for **mixture optimization** that:
  - Lowers cement intensity
  - Reduces disposal
  - Improves performance and longevity
  - Reduces cost!

Use of Industrial By-Products

- Over 15,000,000 tons fly ash used in concrete in US annually (*ACCA 2006*) and growing…
- Slag cement…
- Slag aggregates (from steel making) are also used in concrete…



Concrete Pavements and Sustainability

Renew-ability, Recycling and Reuse

Renew-ability, Recycling and Reuse

- Renewal through grinding
  - Caltrans study suggests an additional 17 years service life gained *(ARA 2005)*
  - 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 *(2008)*

Did you know that 140 million tons of concrete are recycled each year in the United States alone?

Renew-ability, Recycling and Reuse

- Concrete is 100% recyclable
- Recycled concrete aggregate (RCA) can be used in:
  - new concrete
  - subbases
  - granular fill
  - two-lift (FHWA)

- Opportunities for on-site operations that reduce time and energy use…

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)*

Concrete Pavements and Sustainability

Light Colored and Cool

Light Colored and Cool

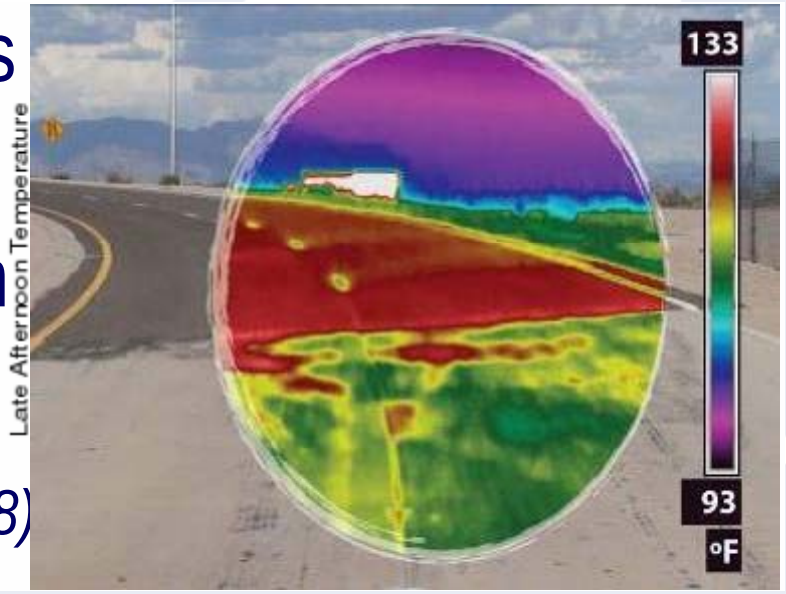
Enhanced Nighttime Visibility:

- Improved pedestrian and vehicle safety
- Reduced lighting and energy requirement:
  - Fewer fixtures or lower wattage fixtures
  - Up to 1/3 energy savings
  - Significant budget impact!

Light Colored and Cool

Urban Heat Island Mitigation:

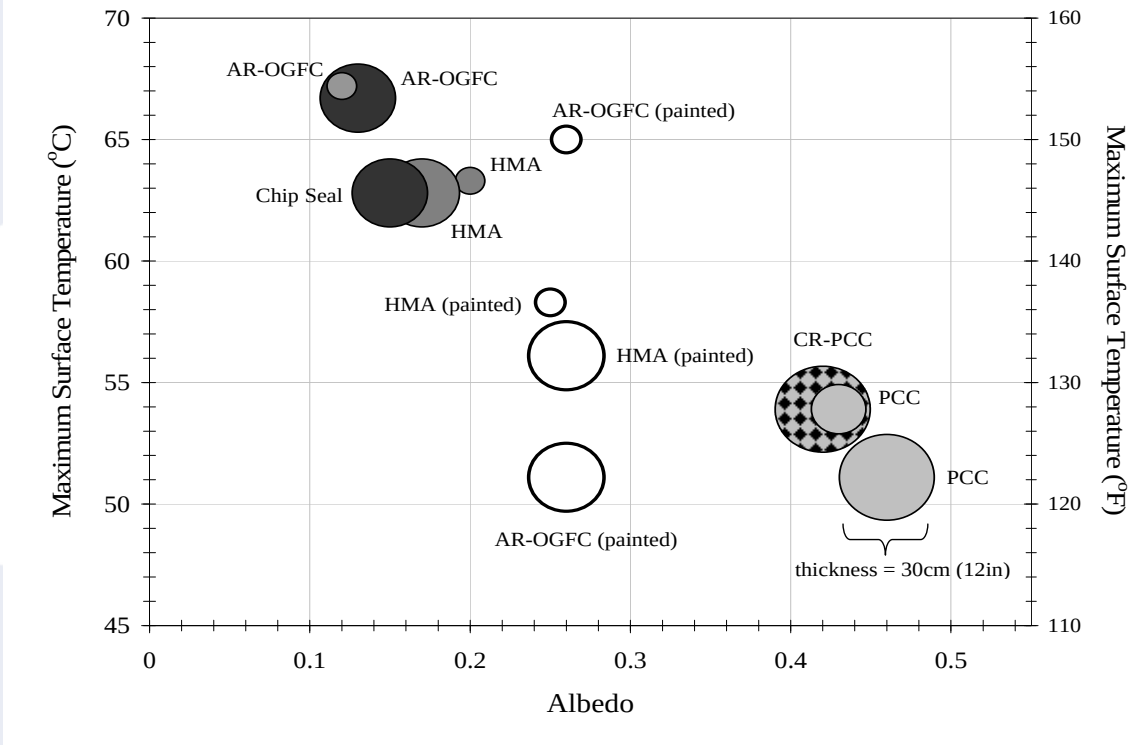
- Urban areas up to 9°F warmer due to UHI
  → greater energy use and resulting pollution
- PCCP is an effective mitigation strategy
  - lower city temperatures
  - lower cooling costs
  - reduce smog formation
- Pot. energy savings
  $2B in US alone *(LBNL'08)*



Light Colored and Cool

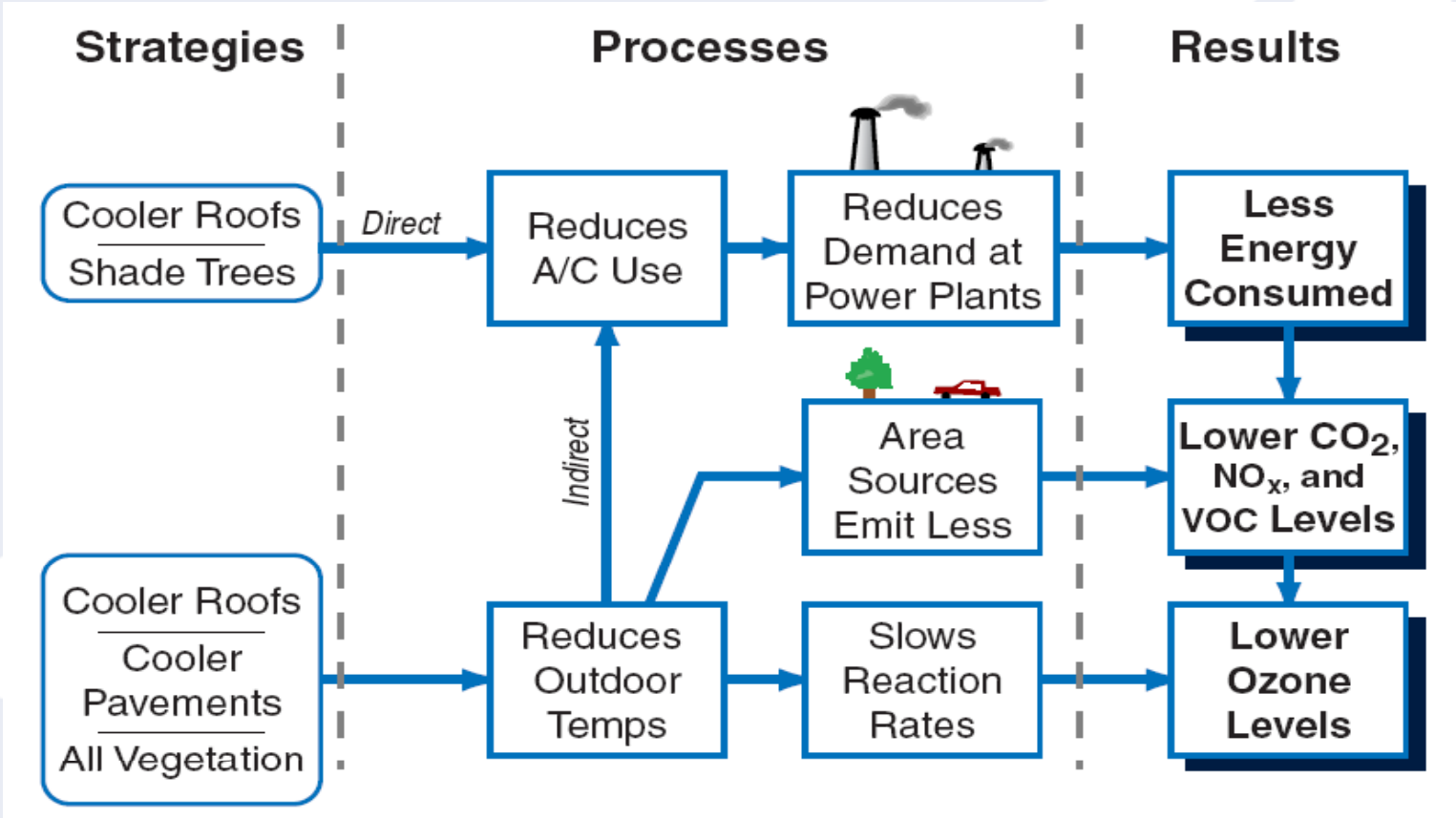
- Recent work at ASU supports this body of work

NATIONAL CENTER of EXCELLENCE
SMART INNOVATIONS FOR URBAN CLIMATE AND ENERGY
ARIZONA STATE UNIVERSITY



Light Colored and Cool

- 5th CA Climate Change Conf (*LBNL and CEC*)



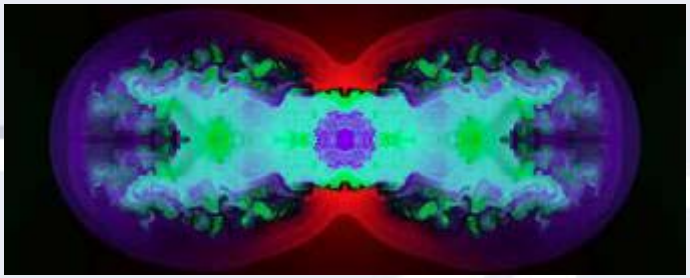
Light Colored and Cool

- 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 planned.

Concrete Pavements and Sustainability

Lower Energy Footprint

Lower Energy Footprint

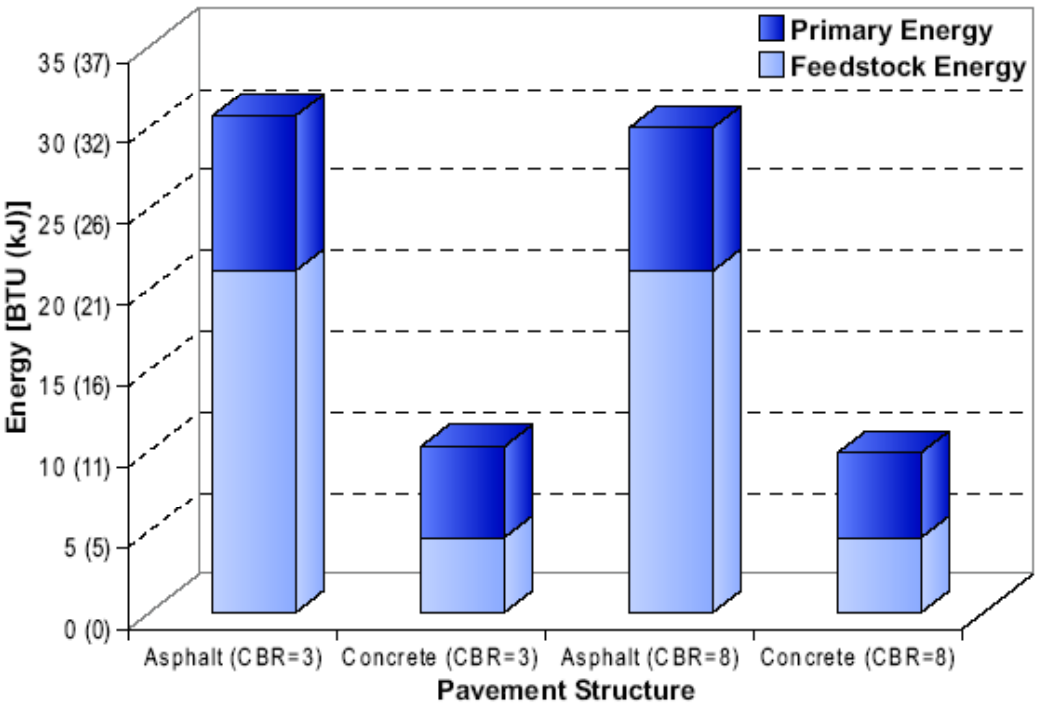


- Embodied primary energy is a measure of all energy use associated with the production, delivery and maintenance of a facility over a specific period
- Includes both feedstock and primary energies
- ASMI analyzed total embodied primary energy for various equivalent concrete & asphalt pavement structures 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
  - Rehabiltation



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

Concrete Pavements and Sustainability

Surface Textures

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

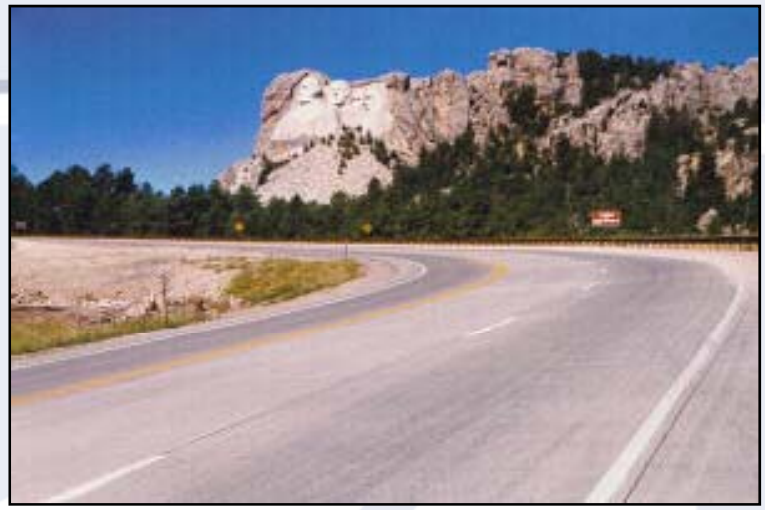
New Quiet Surface Textures

- 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 Pavements and Sustainability

CONCLUSIONS

Summary



Concrete pavement –

a **truly sustainable choice!**

- Lower overall energy footprint!
  - Long lasting and renewable
  - Less fuel and CO_2 to construct
  - Less resource intensive

Summary

- Better fuel economy (trucks/cars)
  - less CO_2, NOx and SOx
- Use of industrial by-products
- Renewal, recycle, recapture
- Better visibility and enhanced safety
- UHI mitigation: huge potential CO_2 offsets!
- New quiet and permeable textures

All these can be realized through design and mixture optimization!

In Conclusion…

- US concrete paving industry strongly supports sustainable development
- Sustainability 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 society!

THANK YOU!

Questions or comments?

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