Common Sense Sustainability for Concrete Pavements

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With thanks to Tom Van Dam (ApTech)
Background

• Concrete is the most commonly used building material on the planet
  ➢ Modern civilization is built on concrete
  ➢ The positive social impacts are immense
• Therefore, it has a relatively large environmental footprint
• Sustainability provides a way to balance the various economic, environmental, and social factors
Pulling on one of the poles takes the system out of balance.

Moving towards the center balances the system.

The Triple Bottom Line

- Economic
- Increased Sustainability
- Environmental
- Social
What makes a Roadway More Sustainable?

The use of practices and materials in concrete pavement that provides a durable pavement over the design life of the pavement, and that:

- minimizes the use of energy and non-renewable resources
- while generating a minimum of pollutants
- in the most cost effective manner possible
- while maximizing the benefits to society.
Sustainable Design

• It is simply good engineering
  ➢ Using limited resources to achieve design objectives
  ➢ Not about perfection, but about balancing competing, and often contradictory, interests

• Considers life-cycle economic, environmental and societal factors

• It’s complicated – get over it
In Addition

Sustainability:
- Is being demanded
- Appeals to a younger workforce
- Allows the industry to communicate the good that is being done
- Makes the concrete industry more competitive
- Drives innovation
- Is an important part of the stimulus package
Common Sense Principles of Sustainability – v 1.0

1. Get smart
2. Design to serve the community
3. Choose what you use
4. Less is more
5. Minimize impact
6. Take care of what you have
7. Innovate
No. 1: Get Smart

• Design for what you need
  ➢ No more and no less
  ➢ Don’t sacrifice engineering quality
• Incorporate design features that ensure that the design criteria are met
  ➢ Holistic approach to design – it is not just thickness
• Incorporate innovative features that enhance sustainability
  ➢ Standardized details
Holistic Concrete Pavement Design
Design Beyond Longevity

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

Adapted from Wathne, ACPA
No. 2: Design to Serve the Community

- Listen to the communities being affected
  - The “community” includes both the human community and natural community
- Design to address the specific needs of the community
  - Now and for the life of the pavement.`t
No. 3: Choose What You Use

- Recycle – zero-waste
- Local first – minimize transportation
- Select the materials to use – don’t let the materials select themselves
  - Understand what is available
  - Import only what you need
Recycling and Reuse

- Concrete is 100% recyclable
- Recycled concrete aggregate (RCA) can be used in:
  - new concrete
  - subbases
  - granular fill
  - two-lift (FHWA)
- On-site recycling reduces time, energy, pollution, and makes money

Adapted from Wathne, ACPA
Waste or Resource?

- Cement and concrete industries consumed 20.59 million metric tons of coal combustion products in 2005 (ACAA)

- Slag cement utilization in 2006 was 3.62 million metric tons (SCA)

- Rice Husk Ash

From J.C. Roumain, Holcim (USA), Inc.
No. 4: Less is More

- All things equal, less material means less impact
- Using less portland cement can improve sustainability
  - Blended (ASTM C595) and performance specified (ASTM C1157) cements
  - Supplementary cementitious materials (SCMs – fly ash, slag, etc.)
  - Aggregate grading
  - Optimized mixture design
Why Does Cement Matter?

- Annual portland cement production for use in the U.S. results in approximately:
  - 110 MMT CO$_2$ and consumes 550 QBTU of embodied energy
  - Domestic cement production is responsible for approximately 1.5% of U.S. total CO$_2$
- Portland cement is responsible for approximately 90% of the CO$_2$ and 85% of the embodied energy in concrete
The Cement Industry...

- Has increased the efficiency of their clinkering process, significantly reducing the CO$_2$ to cement ratio
- Offers blended (ASTM C595) and performance specified (ASTM C1157) cements
- About half of CO$_2$ production is from decomposition of carbonate
- New cements are emerging that may sequester CO$_2$
Why specify cement content?

![Graph showing the relationship between cement content and compressive strength.]
Why specify cement content?

![Graph showing the relationship between w/cm and compressive strength.](image)

- Compressive strength, psi
- w/cm
- $R^2 = 0.6182$
No. 5: Minimize Impact

- Noise – Construction and traffic
- Safety
  - Splash and spray
  - Lighting
- Delays – During construction and rehabilitation
- Emissions
  - Green house gases
  - Pollution
  - Particulates
No. 5: Minimize Impact

- Energy efficiency –
  - Construction
  - Operation
  - Lighting
- Urban heat island effect
Phases of a Pavement’s Life

- Design
- Construction
- Operation
- Rehabilitation
- Recycling, Removal
Factors Affecting Sustainability Design

- Cut and fill
- Design life
- Construction method
- Drainage
- Thickness
- Life cycle
- Cost
- Materials selection
- Capacity
Factors Affecting Sustainability Construction

Virgin materials
Dust
VOC’s
Delay
time
Energy
Noise pollution
Life cycle
Cost

CO₂
Factors Affecting Sustainability Operation

- Maintenance
- Noise pollution
- Water runoff
- Heat island
- Reflectivity
- Safety
- Friction to vehicles
- Capacity
- Longevity
Factors Affecting Sustainability
Repair/Rehabilitation/Removal

Removal = waste disposal

Repair/ Rebuild = similar issues to construction

Recycling in base

Recycling in concrete
No. 6: Take Care of What you Have

- Use the equity already in the existing pavement
- Longevity is a hallmark of sustainable practice
- Well timed maintenance and rehabilitation is essential
- Design to maintain
  - For high volume roadways, accommodate future diamond grinding to extend pavement life
No. 7: Innovate

• Identify problems/opportunities, generate solutions, implement, and reiterate
• Learn from mistakes
• Good specifications
• Evaluate emerging technologies and adopt those with demonstrated promise
• Educate and challenge yourself and your workforce
From Rasmussen et al.
www.surfacecharacteristics.com
Innovative construction approaches

• 2-lift
• Ternary
• Recycle
• …
Quantification

• Rating systems
  ➢ Green Roads, GreenLITES
  ➢ LEED
• Life cycle inventory (LCI)/life cycle assessment (LCA)
  ➢ The future is now (ISO 14000)
  ➢ Need to establish regional data and usable software tools
Concrete Pavement Road Map
Sustainability Track Activities

- A Briefing Document
- A “Best Practices” training manual
- An International Conference – Sept 2010
- Demonstration projects
In Closing, We Must...

- Educate
- Get tools into the hands of practitioners as soon as possible
  - Expect these tools to evolve from some type of checklist/rating system to full life cycle assessment
- Conduct research to fill the gaps in knowledge