Michigan Bridge Conference - 2008

Planning for a Sustainable Bridge

Designing with thought toward the future

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Contents

- **Why be Sustainable?**
- **Material Selection**
  - **Optimize use**
  - **Keep it Local**
- **Durable Structures**
  - **Rapid Construction**
  - **Modular components**
  - **Reduced need for Maintenance**
- **Life-Cycle Focus**
  - **Make decisions based on complete cost**
- **End of Life Planning**
  - **Reuse first, Recycle later**

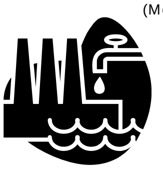
Why be sustainable?

- **So that we may meet our needs without compromising the ability of future generations to meet theirs**

A growing need -

- The human population doubled and doubled again during the 20th century
  - Water usage x 9
  - Sulfur dioxide x 13
  - Carbon dioxide x 14

(McNiell 2000)



Consumption

- **What if everyone in the world consumed resources in the same quantity as the richest nations?**
- Three **additional** Earth-like planets just to sustain **current** resource consumption

(Elkington 1998)

Expansion

- **70% of the land on Earth will be part of the built environment by 2032**

(Chadwick 2003)

Why Conserve?

- U.S. cement consumption in 2002 was 114.4 million tons (PCA 2003) with at least an equal amount of CO_2 released during production

Why Conserve?

- Less than 5% of the annual aggregate demand could be satisfied by making use of crushed scrap concrete (Horvath 2004)

Why Sustainability in Transportation?

- U.S. transportation statistics for 2006:
  - 596,800 highway bridge in U.S.
  - 4,031,429 miles of roadway
  - Average of 3,500 new bridges each year

(Memmot 2007)

Making Changes

- **"Continuing to use the traditional, present-day materials and processes will not enhance the sustainability of our infrastructure"**

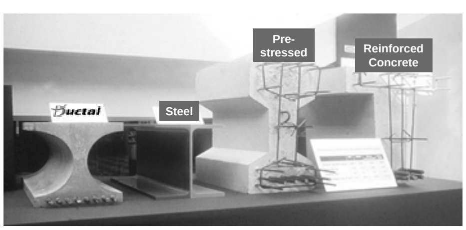
  (FHWA 1997)

Material Selection

- **High performance materials offer:**
  - **Longer spans**
  - **Smaller section size**
  - **High strength/weight ratio**
  - **Reduced life cycle costs**
  - **Less closure time**

Through greater strength and corrosion resistance; allowing greater durability, longer life, and reduced maintenance needs.

Material Optimization



MASS (WEIGHT) OF BEAMS

lbs/lineal ft.	**94**	**75**	**313**	**355**

Optimize use of Materials

- Incorporate the use of high performance materials where they are most needed
  - High stress
  - Corrosion potential
- Optimization may occur at the structural or the elemental level.

Route 224, Lexington, Missouri

- **Hybrid design (HPS only used in high stress regions)**
- **17% weight savings**
- **11% cost savings**
- **138-foot spans**

www.steel.org/AM/Template.cfm?Section=PDFs1&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=1821

Incorporate Local Materials

- **Transportation is the most significant contributor to green-house gases in the U.S.** (Chadwick 2003)
- **Local materials reduce both monetary and environmental transportation costs while boosting local economies.**

Durable Structures

- A durable structure withstands the tests of time through an ability to resist or adapt to environmental pressures.
  - Durable materials
  - Durable components
  - Durable connections
  - Capability for easy maintenance of individual components

Rapid Construction

- Get in, get out, stay out approach to construction
- Reduced traffic congestion
- Lessens impact on the local economy due to detours

Modular Components

- Allows for:
  - Rapid Construction
  - Rapid Rehabilitation
  - Potential for reuse in other applications
- Particular care must be placed on connection details to allow for non-destructive removal and rapid replacement

Reduced need for Maintenance

- A durable structure will require less intensive maintenance less often
- In 2004 $10.5 billion of $12 billion in total bridge capital outlays was dedicated to rehabilitation and replacement of existing highway bridges

(Memmott 2007)

Focus on Life Cycle

- Two life cycle considerations
  - Economic – Life Cycle Cost Analysis (LCCA)
    - Accounts for all monetary expenditures over the lifetime of a structure

Focus on Life Cycle

- Environmental – Life Cycle Assessment (LCA)
  - Environmental measure of all aspects of the product life
    - Extraction of raw materials
    - Processing of raw materials
    - Using product
    - Recycle/disposal of used product
    - Transportation at all stages

Increase Design Service Life

- Achieve the design service life with proper maintenance but without major repair work.
- British standard since 1988 has been a 120 year design life for bridges
- Many places in Europe require at least 100 years for major bridge and tunnel projects

Design for Adaptability and Disassembly

- Use a simple, regular, layout
- Use common, standard members
- Use removable/replaceable connection details
- Use salvaged materials
- Avoid composite systems unless the combined system can be reused

(Webster 2007)

Reuse of Materials

- Where can I find materials to reuse?
  - The Building Materials Reuse Association (BMRA)
    - www.buildingreuse.org
    - Provides contact info for buyers/sellers
    - Certifications/standards for used materials
  - Similar organizations are also available

Reuse of Materials

- Crushed Concrete
  - 66% - road base
  - 9% - asphalt concrete
  - 6% - new Portland cement concrete
  - 3% - high-value rip rap
  - 7% - general fill (low-value products)
  - 7% - other

(Horvath 2004)

End of Life Planning

- During the design phase, determine other uses for bridge components being used
  - What would it take to reuse in another bridge?
  - What other applications could a section be adapted for?
    - Wing, retaining, sound or sea walls
    - Piers (decks and structure)
    - Pedestrian or light-load bridges

End of Life Planning

- Things to keep in mind with Reduce, Reuse, Recycle
  - Just because it's recycled doesn't mean it's better for the environment or for you!
  - Many products must be designed from the beginning for efficient recycling

How do we implement this?

- The concept of sustainability balances sustainable design with cost effectiveness
  - Focus on life cycle cost when making design decisions
  - Consider high performance materials
  - Consider reuse of components

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