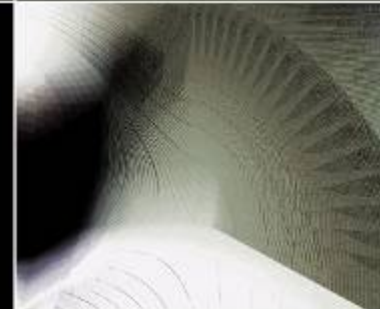


Michigan Bridge Conference - 2007

Sustainable Bridge Design and Construction

Designing with thought
toward the future

CG Gilbertson – Michigan Tech



Contents

- Sustainability Concepts
- Incorporating concepts into bridge design and construction
- Why go Green?

“The world will not evolve past its current state of crisis by using the same thinking that created the situation.” – **Albert Einstein**

What is a Sustainable Construction?

- o Development that meets the needs of the present without compromising the needs of future generations

Elements of sustainable design

- Integration of components
- Holistic viewpoint
- Focus on life cycle
- Tailored design to provide multiple benefits

Integrated Design

- Early coordination between key contributors
 - Architectural
 - Structural
 - Mechanical
 - Construction Contractor
- Why?
 - If Architect locates windows to increase efficiency, smaller mechanical systems could be used, less demand on the structure,...
 - For bridges this is important to share information regarding the use of new materials and technology and creating efficient staging plans.

Holistic Viewpoint

- Include surrounding site environment in design
 - Shelters for public transportation
 - Tie into pedestrian/bike path networks
 - Indigenous landscaping (less irrigation)

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
 - 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

Life Cycle Assessment

- 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

Multiple Benefits

- Try to benefit as many aspects as possible with each design decision
 - Energy efficiency
 - Flexibility of space
 - Environmental impact
 - Quality of life
 - Countless others

How much does this cost?

- A green building typically costs up to 2% more initially than a conventional building
- A \$4 investment (per square foot) in building green nets a \$58 benefit (per sq. ft.) over 20 years:
 - Estimated health & productivity benefits: \$46
 - Operations & maintenance: \$8.50
 - Energy savings: \$5.80
 - Emissions savings: \$1.20
 - Water savings: \$0.50

Making Changes

“Continuing to use the traditional, present-day materials and processes will not enhance the sustainability of our infrastructure” FHWA (1997)

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

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

High-Performance Materials

- High-performance concrete
- High-performance composites
- Aluminum
- High-performance steel

High Performance Concrete

- HPC is a concrete with improved environmental resistance, high strength, or enhanced setting characteristics.
 - Longer spans
 - Smaller cross-sectional area
 - Reduced life-cycle costs
 - More durable – better long term performance
 - Less closure time

Mars Hill Bridge, Wapello County, Iowa

- Ultra-High Performance Concrete (UHPC) Girders
- Very low permeability
- Ductal
- Superior Strength (30 ksi)



www.cement.org/newsroom/2006_bridge_winners.asp

High-Performance Composites

- Fiber Reinforced Polymers (FRP)
- Structural uses for bridges
 - Concrete reinforcing components
 - All-composite bridge decks
 - primary structural members
 - FRP wraps used for rehabilitation projects

Deer Creek, Route 24, Maryland



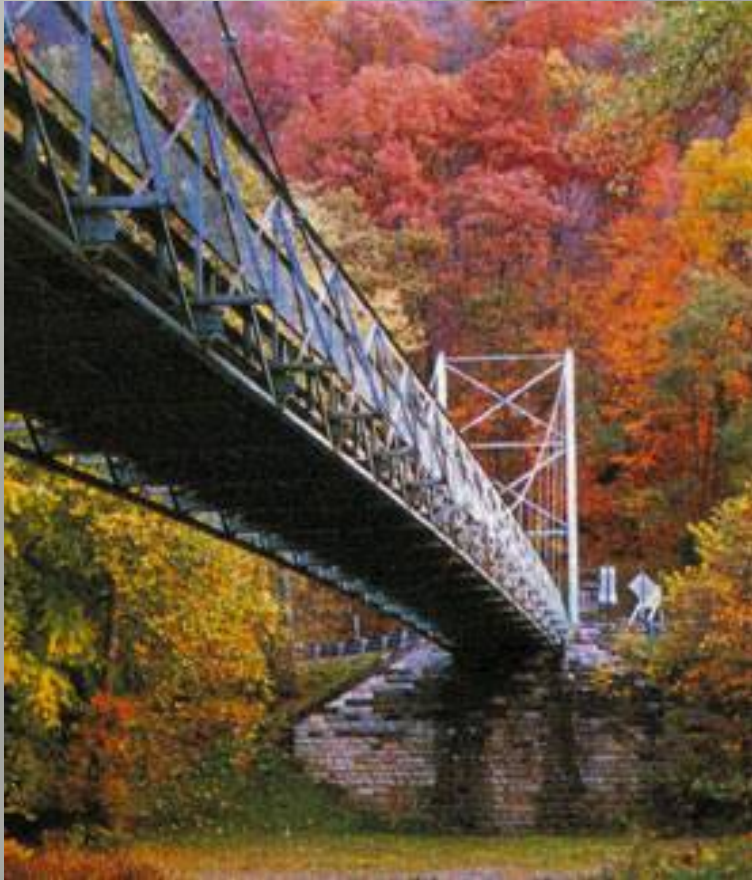
- 2001 FRP Composite bridge deck installation
- 40% lighter deck = more live load capacity

www.tfhrc.gov/focus/may04/01.htm

Aluminum

- Light weight bridge decks
 - High strength/weight ratio
(80% lighter deck than concrete)
 - Requires fewer welds than steel
(reducing potential failure points)
 - Aluminum decks are more corrosion resistant
(some used over 50 yrs)

Corbin Bridge - Pennsylvania



- Historical trust designation
- Previously posted 7-ton weight limit
- 1997 aluminum bridge deck installation
- 80% lighter deck = more live load capacity

www.sns.gov/aboutsns/benefits_engineering.shtml

High-Performance Steel

- New grade of steel: HPS-485W
 - Superior weldability
 - Increased toughness
 - High corrosion resistance
 - Weathering steel considered essential to “high performance”
 - Longer spans/shallower depth (greater clearance below)

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

Why go Green?

- Green design doesn't have to be complicated or impose unrealistic construction/design constraints
- Everyone benefits
 - Owners (Lower utility bills)
 - Occupiers (Better health)
 - People who don't even know what's going on. (Better environment)

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