Sustainable Bridge Design

What does a *more* sustainable bridge project look like?

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APWA Spring 2009 Conference

What We're Covering

- Sustainability and the Bridge Project Life
- Engineer's Impact –Design and Construction
- Engineer's Impact – Rehab/Demo/Replace
- Questions and Opportunities

How We're Defining Sustainability

Resource Management

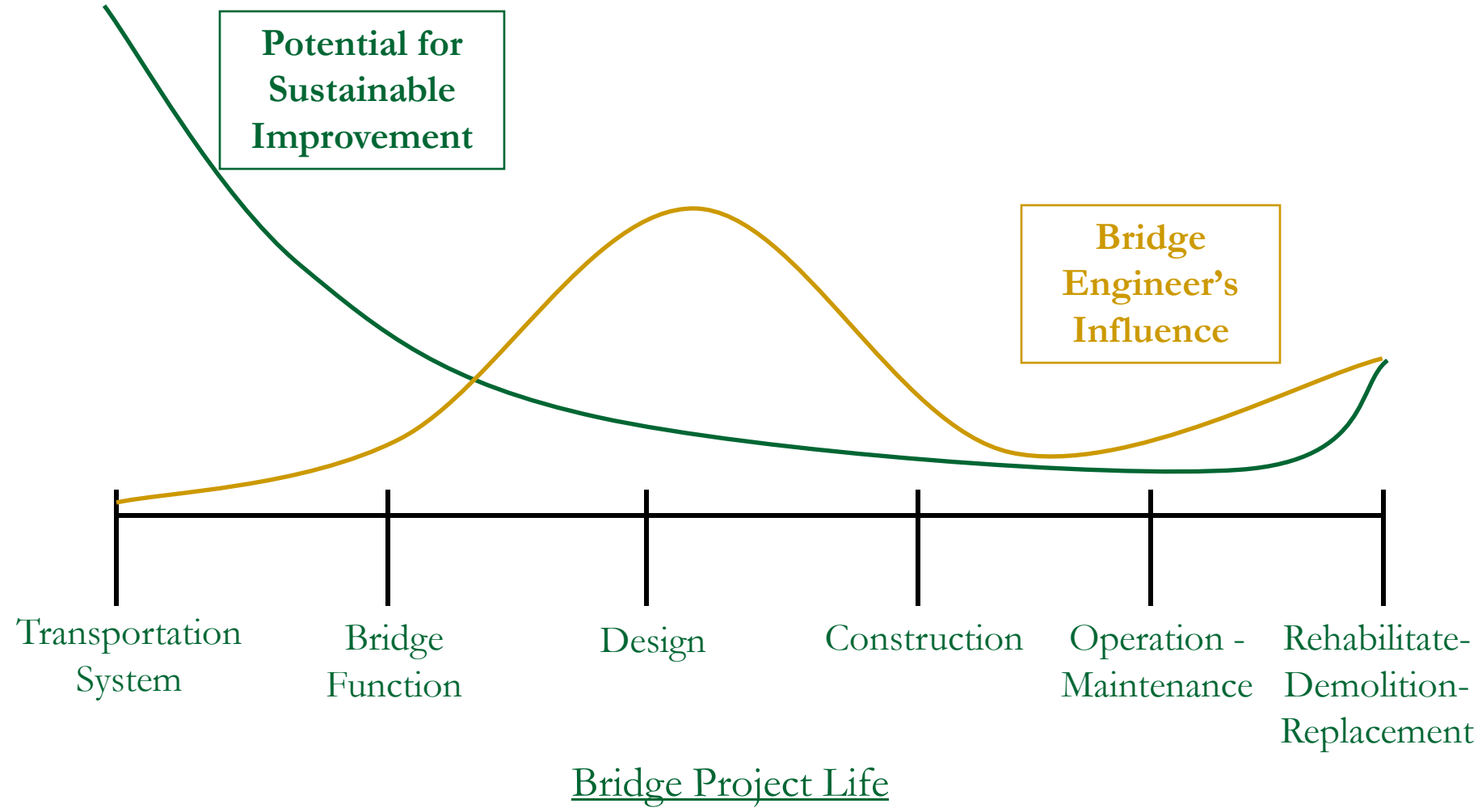
Carbon-Reduction

Energy Use

What We're Not Covering

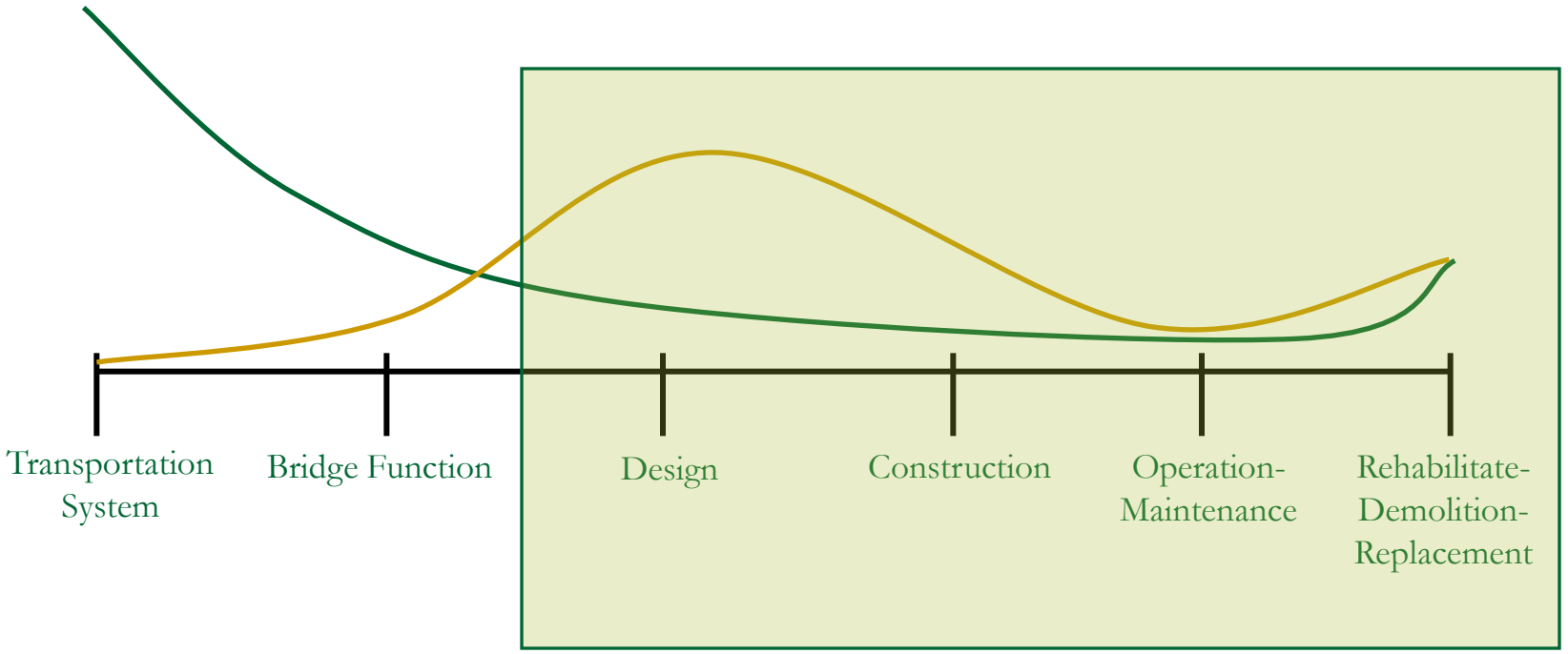
- Why sustainability is important
- Transportation system planning
- Relative benefits of different transportation options
- Sustainability and environmental regulations
- Context Sensitive Solutions
- Sustainable engineering office practices

Sustainability and the Bridge Project Life



Engineer's Impact

- What does a more sustainable bridge project look like?

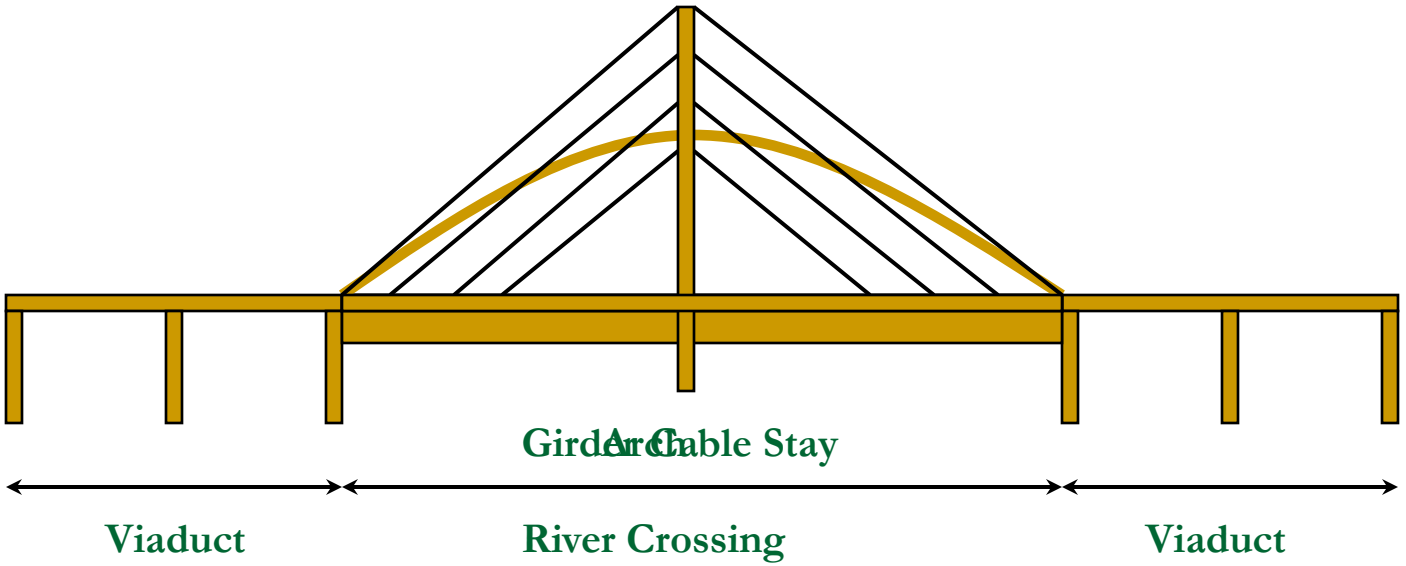


Engineer's Impact - Design & Construction

- What does a more sustainable bridge project look like?
  - Lower energy input

Engineer's Impact - Design & Construction

- What does a more sustainable bridge project look like?
  - Lower energy input
    - Embodied Energy During Construction[1]



Engineer's Impact - Design & Construction

Environmental Impact	Bridge Type	Steel (kWh/ft²)	Concrete (kWh/ft²)
Low (Local Materials, High Recycled Content, etc.)	Viaduct	460	416
	Girder	798	610
	Arch	1,287	886
	Cable-Stay	1,041	558
Average	Viaduct	607	558
	Girder	1,016	791
	Arch	1,599	1,269
	Cable-Stay	1,308	1,134
High (No consideration of sustainable issues)	Viaduct	796	731
	Girder	1,274	1,010
	Arch	1,954	1,574
	Cable-Stay	1,618	1,416

See reference 1.

Some unit reality

1 kWh = 40 watt lightbulb left on for 24 hours

40 kWh = Using up 1 gallon of gas driving a car

14,600 kWh/year = Using 1 gallon of gas per day

100', 2-lane Concrete bridge = 1,700,000 kWh

400', 4-lane, Steel Cable-Stay bridge = 35,000,000 kWh

Engineer's Impact - Design & Construction

- What does a more sustainable bridge project look like?
  - Lower energy input
  - Increased durability
    - Increased designed service life
      - British Standard has been 120 year design life since 1988
      - Many European Locations require 100 year for major bridge and tunnel projects
    - Aesthetic Component

Engineer's Impact - Design & Construction

- What does a more sustainable bridge project look like?
  - Lower energy input
  - Increased durability
  - Simplified Deconstruction

Engineer's Impact - Design & Construction
Concrete

- The Good
  - Very durable
  - Abundant and cheap raw materials
  - Precast Options

- The Bad
  - 5-10% of anthropogenic carbon emissions
  - Not easily recycled
  - Can get pretty ugly

Engineer's Impact - Design & Construction Concrete

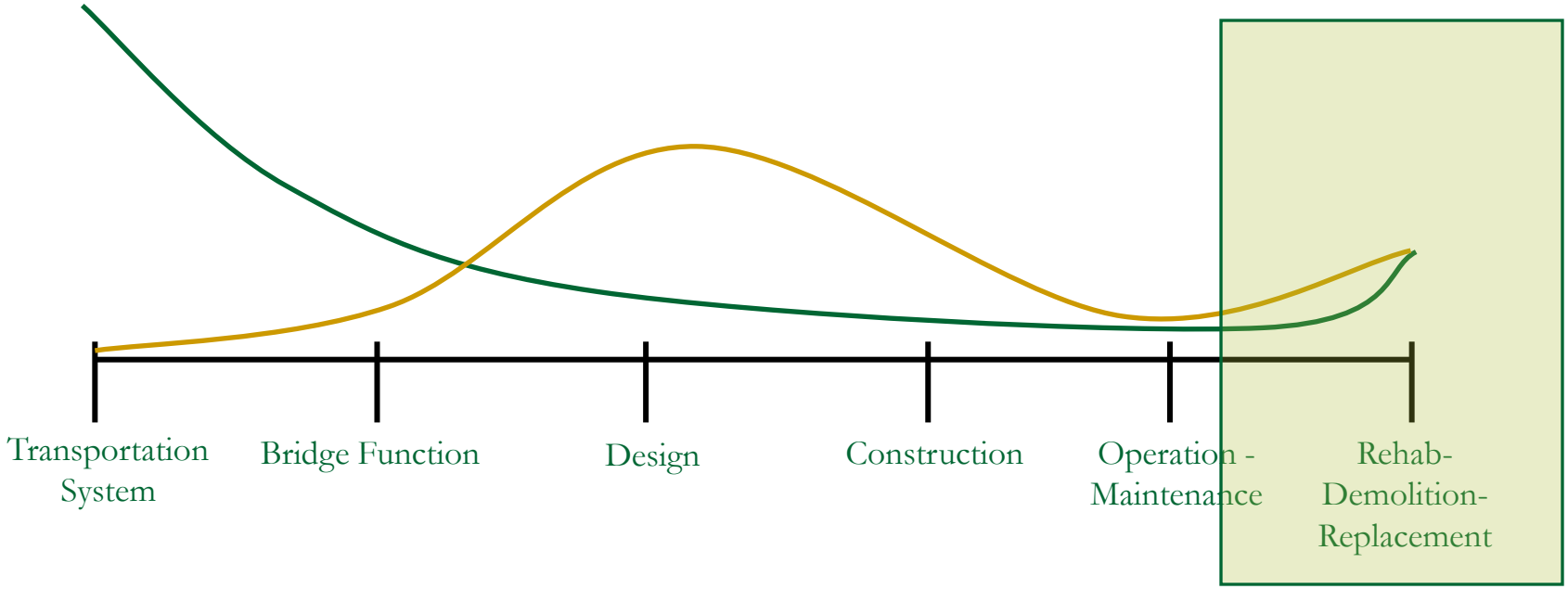
- The Potential
  - "Green-Star" Certified concrete mix plants
  - High Performance Concrete
  - Environmentally friendly concrete
    - Carbon Sequestration in Precast Concrete[3]

Engineer's Impact - Design & Construction Steel

- The Good
  - Highly reuseable
    - Typically 90% recycled content
    - Bolted connections facilitate deconstruction
- The Bad
  - Lead paint on older structures
  - Long term durability

Engineer's Impact – Rehab/Demo/Replace

- The Potential
  - The Rehab vs Replace decision
  - Accurate damage detection
  - Bridge preservation
  - Bridge component re-use

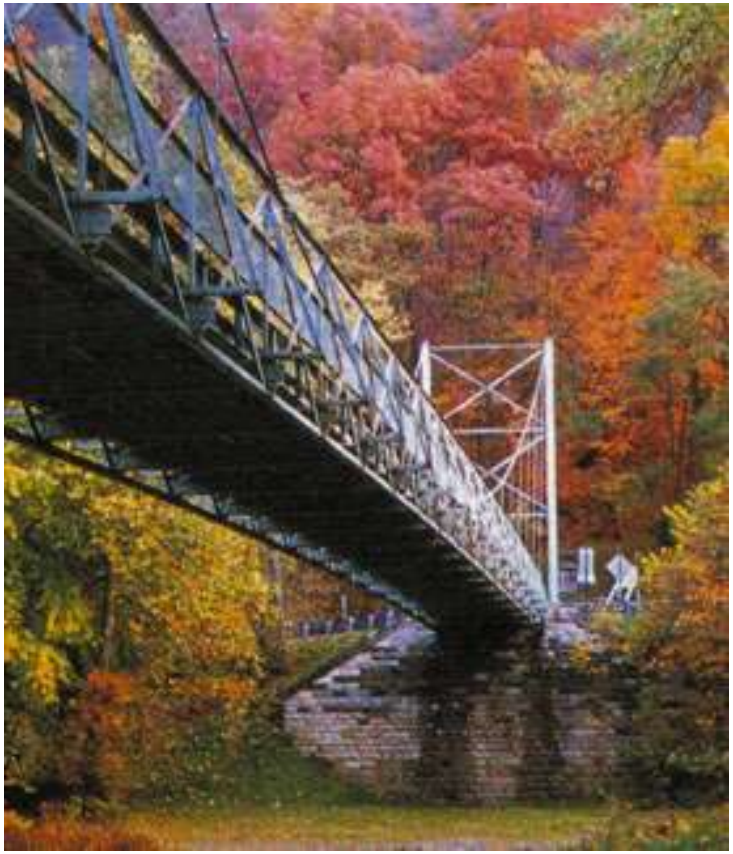


Engineer's Impact – Rehab/Demo/Replace

- The Potential
  - High performance materials – Fiber Reinforced Polymer FRP
    - Broadway Bridge – Multnomah County, Portland OR

Engineer's Impact – Rehab/Demo/Replace

- The Potential
  - High performance materials – Aluminum Decks
    - FHWA report '97 "High Performance Materials – A Step Toward Sustainable Transportation"
    - Lighter Deck = More Live-Load Capacity
    - High Corrosive Resistance



Corbin Bridge - Pennsylvania

Engineer's Impact – Rehab/Demo/Replace

- The European Union – Rail Bridge Program[4]
  - Increase transport capacity
  - Extend the residual service life
  - Enhance management, strengthening and repair systems

Questions and Opportunities

- What can been done to facilitate more sustainable bridges?
  - Investigate/develop specifications leading to extended service life in new bridges
  - Review projects focusing on lower energy input, increased durability and simplified deconstruction
  - More Focus on ease of repair and rehabilitation

Questions and Opportunities

- What other questions do we need to ask?

References

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2. FHWA (1997) Lane, Susan et. al., "High-Performance Materials: A Step Toward Sustainable Transportation" www.tfhrc.gov/pubrds/spring97/high.htm, FHWA Vol. 60, No. 4, Spring
3. Hamilton, T., "A Concrete Fix to Global Warming," Technology Review, http://www.technologyreview.com/Energy/21117/, MIT, July 23, 2008
4. Olofsson, J. et al., Sustainable Bridge – Assessment for Future Traffic Demands and Longer Lives SB9.2, www.sustainablebridges.net, Sixth Framework Programme, Nov. 2007
5. Endicott, W. "A Whole New Cast" Aspire Magazine, www.aspirebridge.com/pdfs/magazine/issue_03/mars_hill_sum07.pdf, Summer 2007 pg 26-34
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