Corrosion Mitigation's Contribution to a Sustainable World

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Presentation Outline

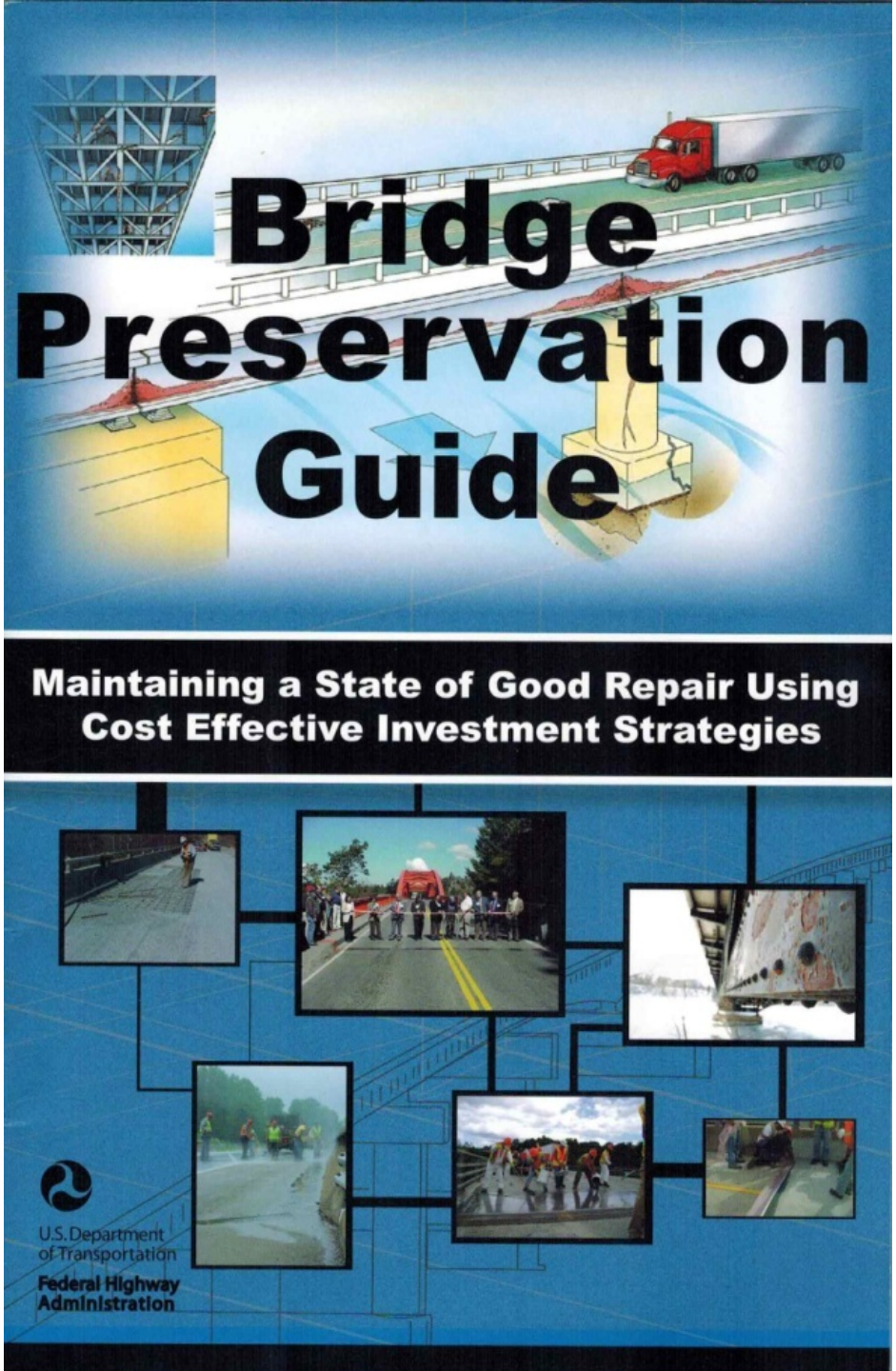
- The Size of the Problem
- Sustainability
- Environmental Impact
- Environmental Benefit of Concrete Repair
- Repair Project Examples
  - Quantified Environmental Impact

Corrosion and Concrete Repair

- Concrete structures deteriorate for many reasons
- Of these causes, Corrosion is the primary cause of concrete damage requiring repair
  - The estimated total cost to address bridge deficiencies in the United States: **$78 billion to $112 billion** (FHWA-RD-98-088)

Sustainability

- ACI 546 Repair Guide being re-written
- Includes a section on Sustainability
  - "The repair and maintenance of concrete structures in lieu of replacement is a green concept and a sustainable philosophy"
  - "The repair of concrete structures meets the objectives of sustainability by conserving existing materials and thereby reducing energy consumption and material waste"



Preservation

- In US, 25% of 600,000 bridges are Structurally Deficient or Functionally Obsolete
- 30% of bridges have exceeded their 50 year design life
  - Need repair, rehabilitation or replacement

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Durability

- Durability, Extended Service Life and Efficient Use of Resources are all ways to discuss and support the values of Sustainability
- ACI 562 (Concrete Repair Code) has an entire chapter devoted to Durability

Environmental Impact of Concrete

- Concrete is the most widely used man-made product in the world
- 7.5 Billion tons per year (~4 Billion m^3)
- Huge consumer of raw materials and energy
  - Cement
  - Aggregate
  - Concrete production and transport
  - Steel production is also energy intensive

Carbon Dioxide Footprint

- Cement production = 1.5 Billion tons/year
- Production of cement produces approx 1 ton of CO_2 per ton of cement
  - (Total CO_2 ~ 1.5 Billion tons CO_2 per year)

Carbon Dioxide Footprint

- Annual CO_2 production
  - Cement: 1.5 Billion tons CO_2 per year
  - Aggregate: ~ 50 Million tons CO_2 per year
  - Ready Mix: 150^+ Million tons CO_2 per year
  - Rebar: 200 Million tons per year
- Total CO_2 produced: ~ 2 Billion tons / yr

Other Emissions

- Carbon Monoxide: 10 Million tons / year
- Nitrogen Oxides: 30 Million tons / year
- Sulfur Dioxide: 29 Million tons / year
- Volatile Organic Compounds: (VOC's)

  2 Million tons per year
- Thermal pollution is also significant.

Thermal Pollution

- Thermal pollution from concrete production is ~ 8 Billion GJ / yr.
- 1J = A very small amount of heat
- 1 GJ = A Lot of Heat
- This is enough heat energy to raise the temperature of 1 million square kilometers (400,000 square miles) of water, 1 meter (3 feet) deep by 1°C (2°F) / year.

Responsible Use of Concrete

- Despite the environmental impact, concrete is one of the most environmentally friendly materials available if it is used properly.
- Concrete is extremely durable and has the ability to last for many years.


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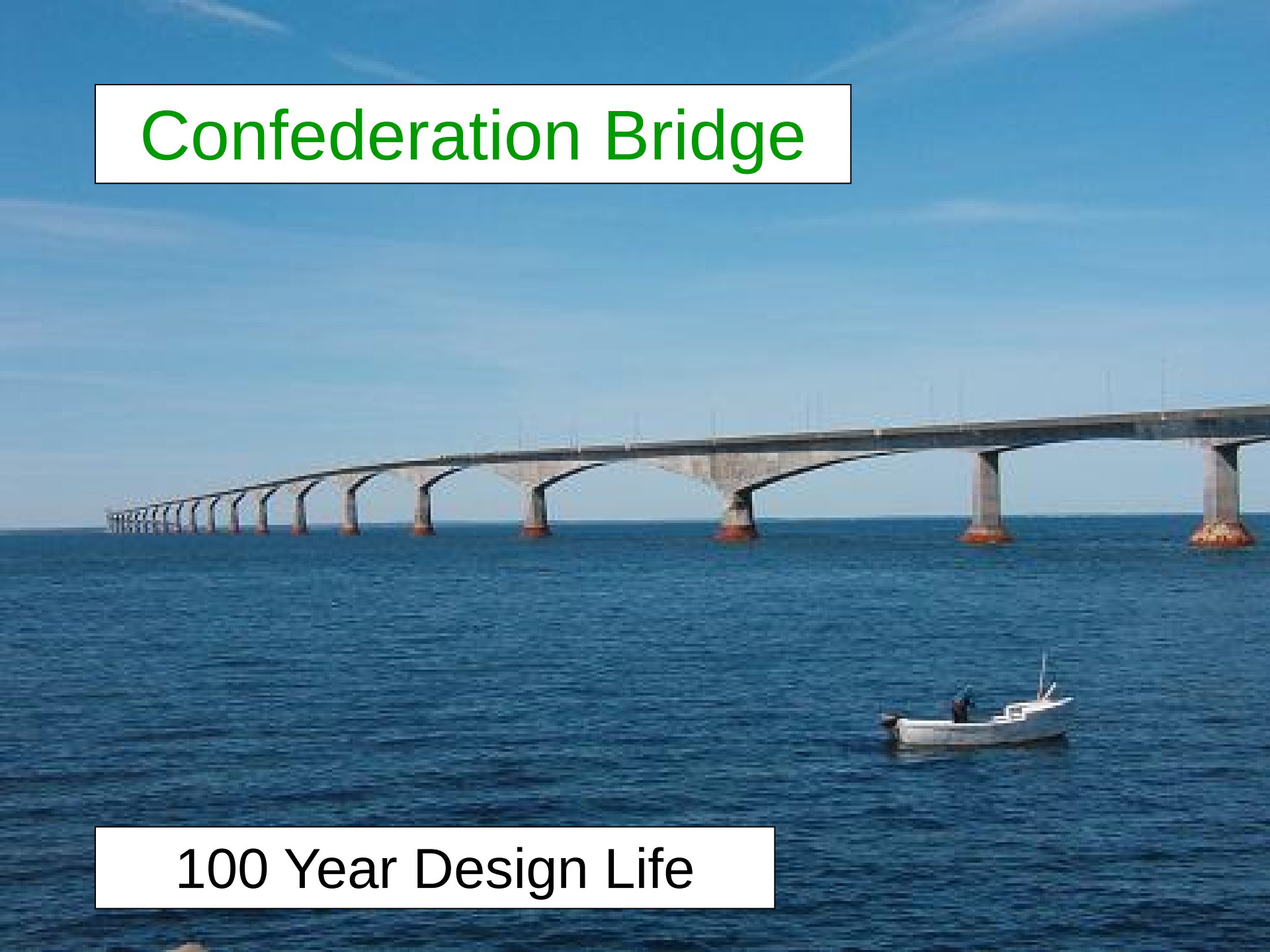
Responsible Use of Concrete

- It is possible to build long lasting structures but most structures we build do not last as long as they can.
- The average bridge deck which is replaced in the US is 35 years old.

Responsible Use of Concrete

- We can reduce the demand for concrete and it's negative impact on the environment by:
  - 1. Not building structures, or
  - 2. Building more durable structures, or
  - 3. Extending the service life of existing structures.
- This is a challenge but it is possible if we make it a priority.


Confederation Bridge
100 Year Design Life

Cathedral of Our Lady of the Angels

500 Year Design Life

ICRI Project of the Year
Norcure® Electrochemical Chloride Extraction

Historic Rainbow Bridge
Cascade, ID

50 Year Life Extension to a 75 Year Old Structure


DuraFlex


NORTHERN & PACIFIC

Rainbow Bridge Rehabilitation

- 50 year service life extension.
- 1,809 yd^3 of concrete were maintained in service.
- Reduced CO_2 emissions by ~ 900 tons.
- Prevented the release of 4,800 GJ of heat. (enough heat to boil 3 Olympic Pools)
- Equivalent to annual emissions of 180 people

Port of Canaveral

North Cargo Piers

Scope of Work

- Pile Caps
- Prestressed Piles
- Precast Deck Units

Pile Cap Repair

- 6,500 ft of pile cap repair
- Remove bottom 6 in
- Install distributed galvanic anodes
- Form and Pour Repair

Deck Protection

- 60,000 ft2 area protected
- Precast / Prestressed Hollow Core Slabs
- Light sandblast cleaning
- Metalized zinc anode
  - 25 mil thickness
- Humectant activator
  - Attracts moisture to zinc/concrete interface
- Inorganic zinc coating
  - Protect from self corrosion

Port of Canaveral Rehabilitation

- 20 year service life extension.
- 8,700 yd^3 of concrete were maintained in service.
- Reduced CO_2 emissions by 4,350 tons.
- Prevented the release of 23,200 GJ of heat. (enough heat to boil 15 Olympic Pools)
- Equivalent to annual emissions of 870 people.

Call to Action

- This is Important
- Think about the Reality,
- Accept Responsibility, and
- Take Action

Thank You