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SAND • CEMENT
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2024
FALL CONVENTION

DENVER, COLORADO | OCTOBER 22-25, 2024

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QUANTIFYING THE SUSTAINABILITY BENEFITS OF EXTENDING SERVICE LIFE OF CONCRETE STRUCTURES

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Live Content Slide

When playing as a slideshow, this slide will display live content

Poll: Do you need to be a PhD expert to quantify the benefit of preserving and extending the life of concrete structures?

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Pantheon, Rome, Italy
Commissioned: 27 BC and 14 AD
Completed: 126 AD

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CONCRETE

- Concrete is the most widely used man-made product in the world
- 33 Billion tons per year
- Huge consumer of raw materials and energy
  - Cement
  - Aggregate
  - Concrete production and transport
  - Steel production is also energy-intensive

ENVIRONMENTAL IMPACT

- Consumes raw materials and energy
- Total CO_2 produced: ~ 8.4 Billion tons / year
- Other Emissions
  - Nitrogen Oxides: 6.6 Million tons per year
  - Sulfur Dioxide: 2.2 Million tons per year
- Thermal pollution is also significant
  - Enough Heat to Boil 52 Million Olympic Swimming Pools

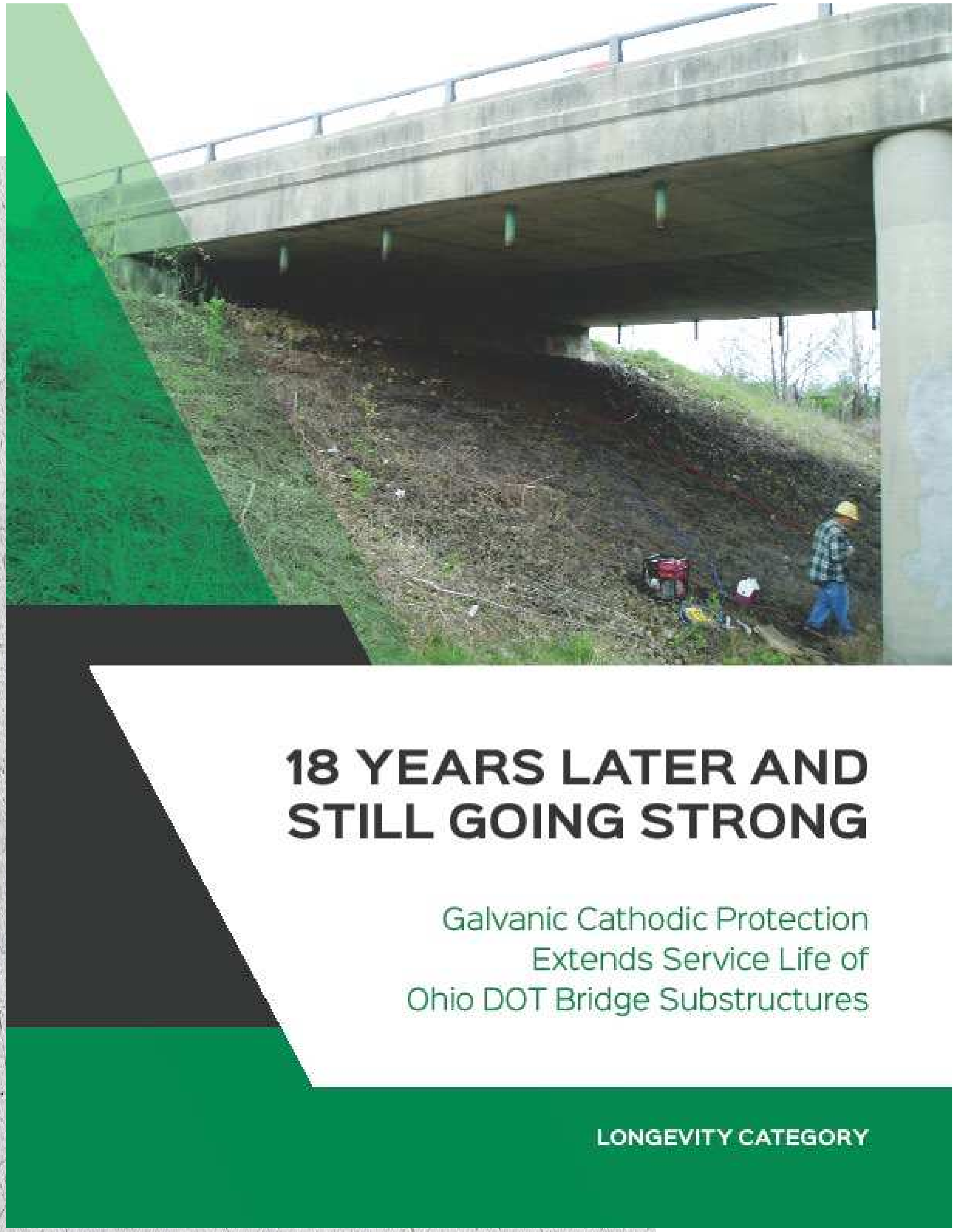
- Many concrete structures are replaced within 50 years due to deterioration.
- Reinforcement corrosion is the main cause of structural issues and limits service life.
- This bridge, less than 50 years old, has undergone poor repairs.
- Durability was not considered, leaving the structure in terrible condition.

SUSTAINABILITY

- Replacing concrete structures we already have is not beneficial for society.
- Keeping existing concrete structures in service is a sustainable practice and saves resources for future generations to use.
- In addition to the philosophical benefits of sustaining concrete structures, we can quantify the impact of our decisions.

FOR EVERY 10,000 YD^3 WHICH IS PRESERVED…

- 20,000 tons of rubble is kept from landfill
- 20,000 tons of natural resources are conserved
- Thousands of pounds of pollutants like SO2 and NO2 are not generated
- Enough potable water for the daily needs of 2,500 people is conserved
- Enough heat to boil 30 Olympic-sized swimming pools is not released
- The annual carbon dioxide footprint of 1,250 people is offset



GALVANIC ENCASEMENT OF I-75 BRIDGE ABUTMENTS

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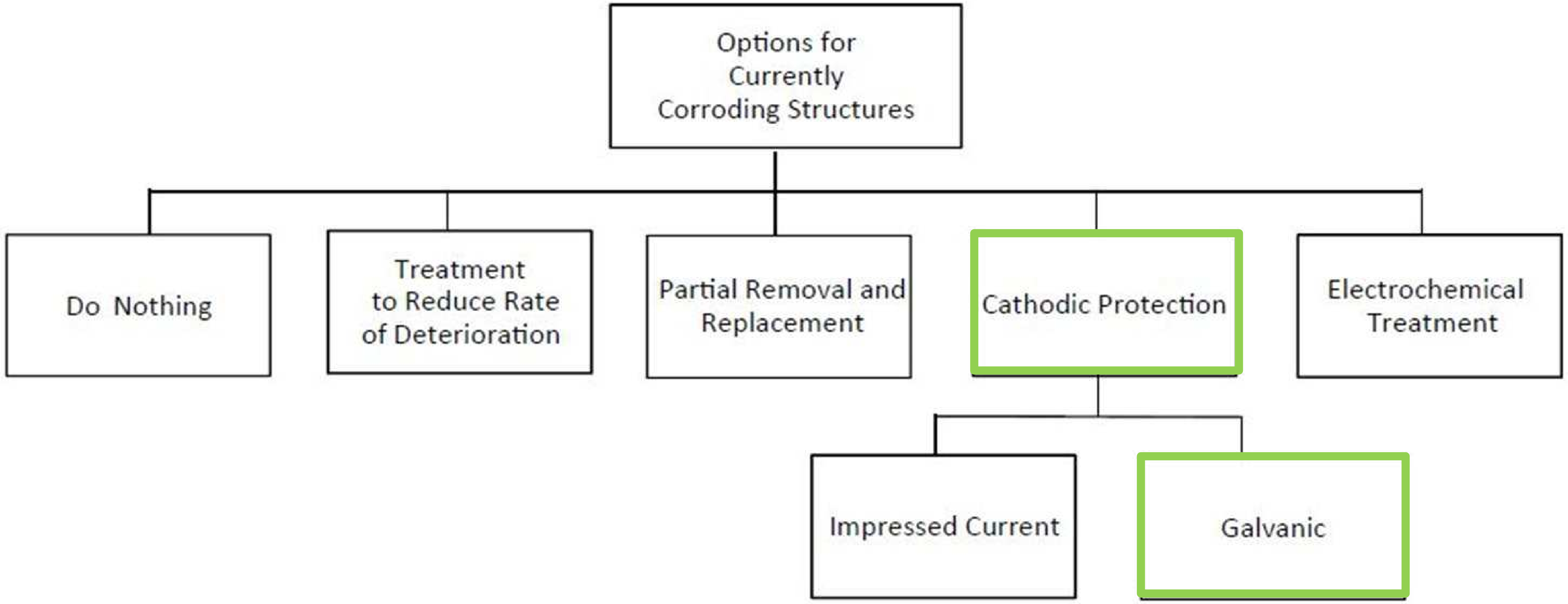
ABUTMENT CONDITIONS
CIRCA 2005

STRATEGIC HIGHWAY RESEARCH PROGRAM 2: PROJECT R19A



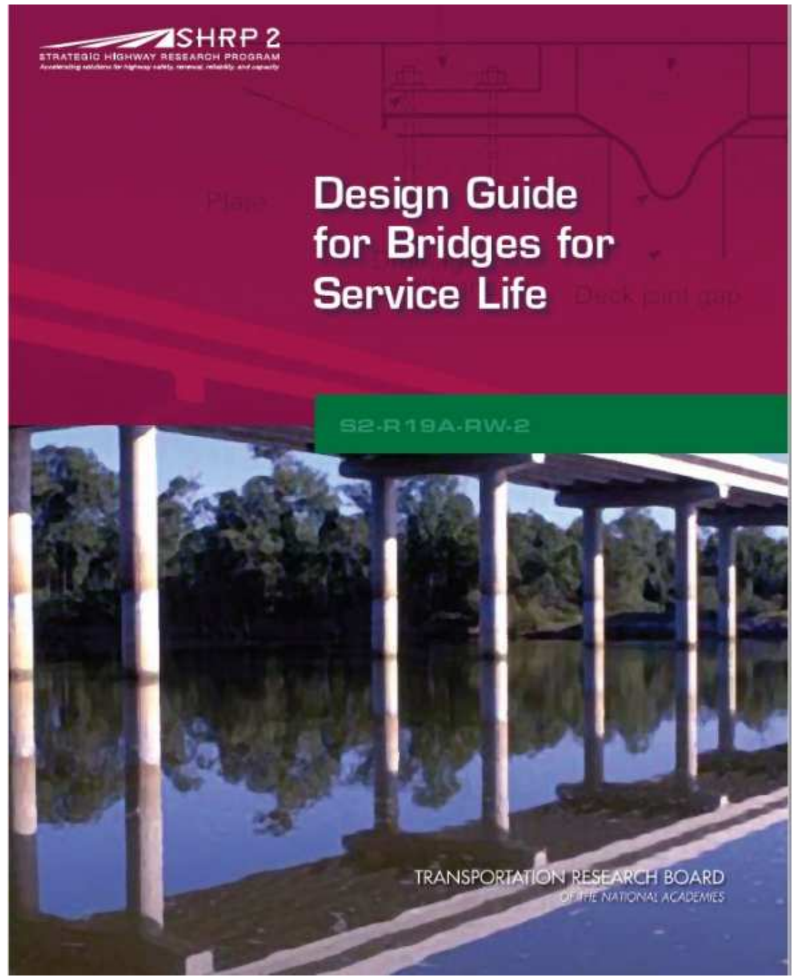


Figure 5.13. *Options for corroding structures.*

SPALL REMOVAL

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GALVANIC ANODES AND SUPPLEMENTAL REINFORCING INSTALLED

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FORMS
INSTALLED

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COMPLETED REPAIR 2005

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GALVANIC CATHODIC PROTECTION

PERFORMANCE SUMMARY

Date	Temperature, degree C	On Potential E_{ON}, mV	Instant Off E_{IOFF}, mV	Current Density Icp, mA/m^2	Polarization, Epol, mV
5/6/2005	(*Native*)		*-654*	37.7	
7/20/2005		-1061	-990	14.0	346
8/16/2005	30.6	-1136	-998	12.7	344
10/26/2005	12.2	-1082	-1023	5.4	369
12/7/2005	10.6	-982	-964	2.9	310
5/1/2006	13.9	-1051	-967	7.3	313
12/20/2006	4.6	-1176	-1113	3.7	459
5/30/2007	26.3	-1212	-1104	7.5	450
9/20/2007	23.9	-1238	-1136	9.1	482
12/19/2008	4.4	-1174	-1105	3.5	451
7/9/2009	23.3	-1146	-1125	2.8	471
5/11/2010	12.2	-1160	-1139	3.4	485
10/16/2011	22.2	-1193	-1142	5.9	488
4/22/2013	21.1	-1113	-1079	3.1	425
3/24/2015	1.7	-1060	-1035	2.0	381
9/17/2018	25.6	-1044	-1007	5.3	353
9/9/2020	26.7	-1036	-1005	3.6	351
8/23/2022	26.7	-1008	-986	2.0	332

NACE Criteria for Cathodic Protection is 100+ mV Polarization Shift

I-75 OVER KIRKWOOD ROAD 2022

No Deterioration despite leaking joint and weep holes

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PROJECT SUMMARY

- Bridge maintained in service
- One-step repair with galvanic protection
- Cost Comparison
  - Rehabilitation with anodes: $319,000
  - Abutment Replacement / Temporary Shoring: $427,000
  - Replacement of structures: $4,500,000
- Minimal impact on traffic or environment
- 17+ Years of performance, continues to be monitored

OHIO DOT BRIDGE

- 850 yd3 (650 m^3) of concrete per bridge was maintained in service. Two bridges per location.
- 3,400 tons of rubble was not produced per location.
- CO_2 emissions were reduced by 928 tons per location.
- Thousands of pounds of pollutants like SO_2 and NO_2 and additional heat was not released into the atmosphere.
- 928 tons of CO_2 is equivalent to the annual emissions of 212 people.
- They have used this repair in over 50 locations which has resulted in savings equivalent to the annual emissions of over 10,000 people.

WESAVESTRUCTURES.INFO

Inputs				
Volume of concrete to be preserved	8700	yd3	6651	m3
	Calculate		Calculate	
			Print	PDF
Outputs				
Emissions				
Concrete CO2	2290	US tons CO2	2075	metric tons CO2
Steel CO2	2466	US tons CO2	2235	metric tons CO2
Carbon Dioxide	4756	US tons CO2	4310	metric tons CO2
Equivalent to annual CO2 emission of:	1081	people	1078	people
NOx (as NO2)	8480	lbs	3782	kg
SO2	2368	lbs	1056	kg
Total Pollutants	9524298	lbs	4314929	kg
Waste Generation				
Solid Waste (Rubble)	17618	US tons	15962	metric tons
Energy (heat generation from cement production, cement hydration, and steel production)	20746	GJ	19691	GJ
Equivalent energy to boiling	26	Olympic Pools	24	Olympic Pools
Natural Resources Required				
Fine aggregate	4581	US Tons	4150	metric tons
Coarse aggregate	7223	US Tons	6545	metric tons
Cement	3915	US Tons	3492	metric tons
Steel	1409	US Tons	1277	metric tons
Total tons	17128	US Tons	15464	metric tons
Potable Water	220120	gal	814748	liters
Equivalent to daily water usage for:	2201	people	2037	people

WeSaveStructures.Info is an educational website that promotes the benefits of preservation technologies to extend the service life of concrete structures. This website has a useful Environmental Impact Calculator to help evaluate preservation options.

PEx

Center of Excellence for Preservation and Service Life Extension

PEx

Center of Excellence for Preservation and Service Life Extension

Our Mission

To drive awareness, education, technologies, and actions to preserve and extend the service life of concrete structures.

P+Ex Established

- Non-profit Center of Excellence established
- Want broad engagement and involvement of industry, academia, institutions, organizations, government and independent individuals
- Funded by industry partners, individuals and organizations who wish to support this initiative

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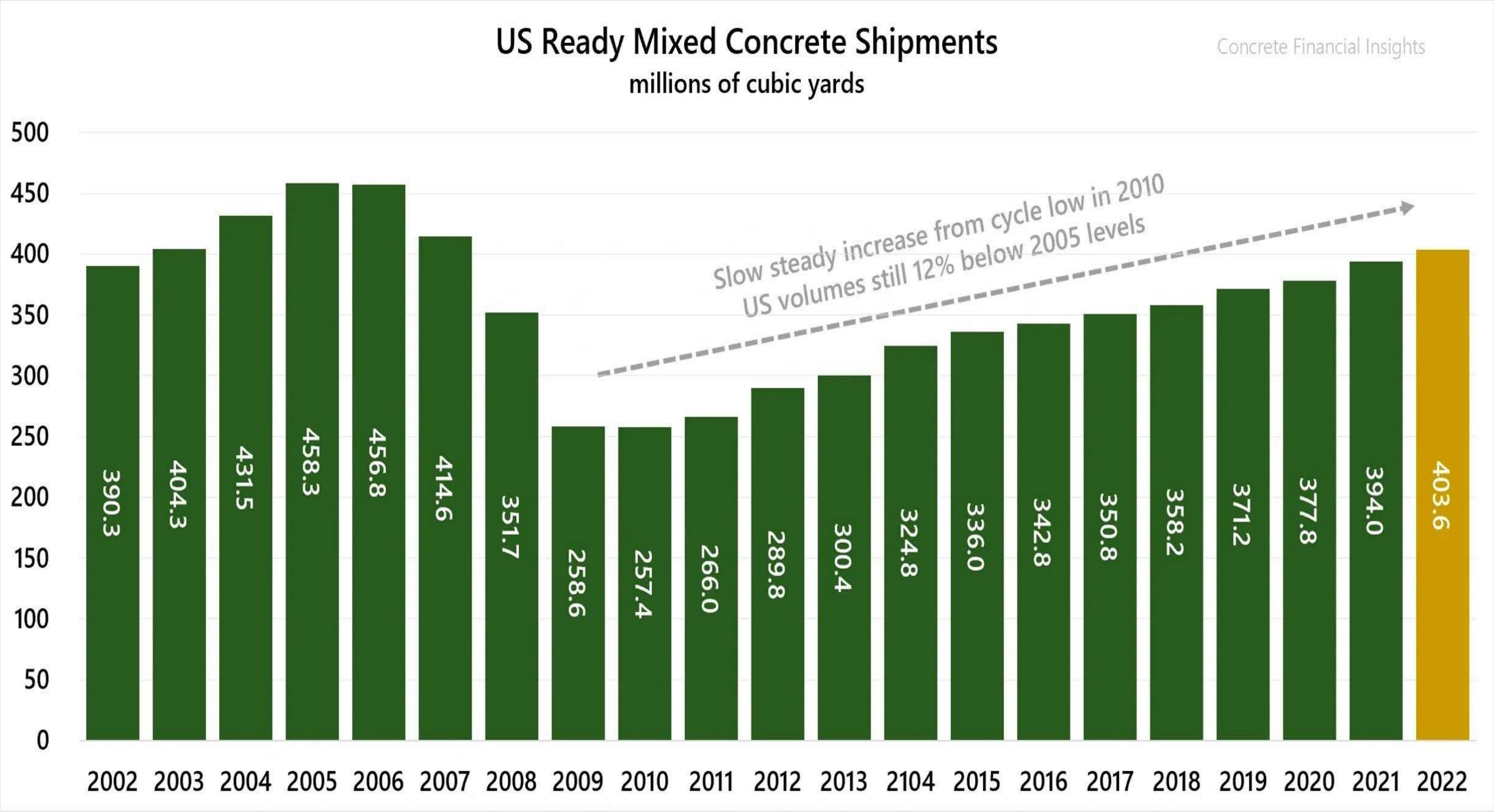
Ready Mix Consumption in USA Only 2.3% of World



Source: NRMCA utilizing US Geological Survey data – updated March 2023

CO_2 Impact of Extending Service Life

- **400 Million yd3** of new concrete placed each year in USA
  - Contributes **80 Million Tons of CO_2** to the atmosphere (*source PCA, 400# CO_2/yd^3*)

- **12 Billion CY** Current inventory of Existing Concrete in USA
  - = **2.4 Billion Tons of CO_2**
  - Repairing, Protecting, Rehabilitating, Preserving = Extended Service Life
  - Every day the service life of the existing concrete inventory is extended **Saves 6.6M tons of CO_2***

* less the CO_2 required to preserve the existing concrete which is generally minimal

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Impact

SERVICE LIFE Extension is a **NET REDUCER** of CO_2 Emissions

Also Saves Resources for Future Use and Offsets the Need to Demolish and Replace what we Already Have

Vision 2020 Goal, ICRI Committee

SUSTAINABILITY FOR REPAIRING AND MAINTAINING CONCRETE AND MASONRY BUILDINGS

BY ICRI COMMITTEE 160, SUSTAINABILITY: DONALD (LEO) WHITELEY (CHAIR), KURT GOETHERT, FRED GOODWIN, H. PETER GOLTER, JOHN KENNEDY, TANYA WATTENBURG KOMAS, JESSI MEYER, MATTHEW PETREE, BRYAN SMITH, STEPHAN TREPANIER, DAVID WHITMORE, AND PAT WINKLER

Sustainability is meeting the needs of the present without compromising the ability of future generations to meet their own needs. The purpose of this white paper is to educate manufacturers, contractors, design professionals, and building owners on the benefits of sustainable maintenance, repairs, and adaptive use for concrete and masonry buildings.

INTRODUCTION

Sustainability has encouraged a plethora of responses toward meeting the goals of living more gently with the Earth. The building industry has an undeniably important place in this dialog. As such, new technological solutions have emerged in all corners from cement production to high-rise building design, new and refined models have been developed to calculate efficiencies from cradle to grave, and clearer understandings have emerged that illuminate how we produce and interact with our built environment. These endeavors often highlight the inherent advantages of building with durable materials such as concrete and masonry. This paper will make the case that proactive protection, maintenance, and repairs offer the ultimate inherent sustainable advantages in terms of cost, longevity, energy, and even cultural responsibility.

Sustainable design and construction is a rapidly evolving area of importance to Architects, Engineers, Contractors, and Owners (A/E/C/O) and others involved in the design and construction industry. New building codes and certification programs attempt to define, and often place, different parameters around what is required for a building project to be considered "sustainable." As sustainable design and construction practices continue to evolve, the repair project team will be faced with an increasingly diverse set of standards to apply to their projects.[1] Green building codes, such as the 2010 California Green Building Standards Code,[2] establish mandatory baselines for energy and environmental performance that all building projects are required to meet. The International Code Council (ICC) issued the 2012 International Green Construction Code (IgCC).[3] The IgCC is the first model code that includes sustainability measures for the entire construction project and its site, from design through construction, certificate of occupancy, and beyond. The new code is expected to make buildings more efficient, reduce waste, and have a positive impact on health, safety, and community welfare.

Sustainable design is moving into the mainstream of many jurisdictions and federal programs. Presidential Executive Order 13514,[4] "Federal Leadership in Environmental, Energy, and Economic Performance," issued October 5, 2009, establishes an integrated strategy toward sustainability in the federal government. "The U.S. General Services Administration (GSA) is committed to achieving President Obama's sustainability agenda. GSA will achieve a Zero Environmental Footprint (ZEF): it will eliminate its own impact on the natural environment, and use its government-wide influence to reduce the environmental impact of the Federal government."[5] "GSA's mission is to use expertise to provide innovative solutions for our customers in support of their missions and by so doing foster an effective, sustainable, and transparent Government for the American people."[5] The impact that this mission presents is enormous to the built environment. As of September 30, 2010, the total space owned or leased by GSA was over 414 million ft^2 (39 million m^2). The U.S. Army Corps of Engineers states, "As a prominent Federal entity, a key participant in the use and management of many of the Nation's water resources, a critical team member in the design, construction, and management of military and civil infrastructure, and as responsive members of the Nation's citizenry, the U.S. Army Corps of Engineers (USACE) strives to protect, sustain, and improve the natural and manmade environment of our Nation, and is committed to compliance with applicable environmental and energy statutes, regulations, and Executive Orders."[6]

With broadening awareness and understanding, sustainable thinking demands that we consider repairing and preserving existing structures whenever possible, rather than building new, simply because of perceived need, technological "why not," or misguided intentions. Some of the most useful, responsible, and durable building projects begin with existing structures. Blair Kamin, the Pulitzer Prize-winning architecture critic of the *Chicago Tribune*, puts the idea of a new, broader reality squarely in perspective in his discussion about preservation versus conservation (building green) when he suggests that these endeavors are really about the same ends. The argument is "not technical but cultural. It's about how we live and how we ought to navigate between perilous extremes: not with overzealous ideology but with an enlightened pragmatism that reshapes and reinvigorates old ideals in response

1

"Sustainability is meeting the needs of the present without compromising the ability of future generations to meet their own needs. The purpose of this white paper is to educate manufacturers, contractors, design professionals, and building owners on the benefits of sustainable maintenance, repairs, and adaptive use for concrete and masonry buildings."

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130 Sustainability Document

The thoughtful extension of the life of existing structures through careful repair and a commitment to long-term maintenance is a responsible answer to the reality of reducing our impact on the environment.

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130 Sustainability Document

Therefore, the longer these buildings can stay in service, the more the environmental impact is diminished over their full life cycle. Protective measures during construction and proactive maintenance can prevent the need for repairs and are ultimately the most sustainable approach. Repairs themselves contribute to a structure's overall environmental impact but are much less impactful than a "demolish and rebuild" approach that is often required for structures that have been allowed to deteriorate.

130 Sustainability Document

PROTECTION AND PREVENTATIVE MAINTENANCE

The most sustainable management approach for buildings is to diligently perform preventative maintenance to avoid, or at least minimize, the need for repairs. In some cases, the original design and construction included measures to proactively protect the building (such as protection against the intrusion of moisture or contaminants and corrosion prevention measures). However, these measures are often not included to reduce the initial construction cost, despite the significantly lower life-cycle impact that would ensue over the longer term.

Preventative maintenance is required whether or not the original design included adequate protection measures. For

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Sustainability Initiative is Largely Unfinished

- A good whitepaper on sustainability was written
- The concrete repair industry was not ready to do more on this issue at that time
- Societal expectations and corporate responsibilities have evolved
- Now there is a need to follow through and address this issue

Join Us

- Join us in developing solutions for a sustainable future
- We want broad engagement and involvement of industry, academia, organizations, government and independent individuals
- Join us for our Road Mapping Workshop this afternoon

THANK YOU

FOR YOUR ATTENTION

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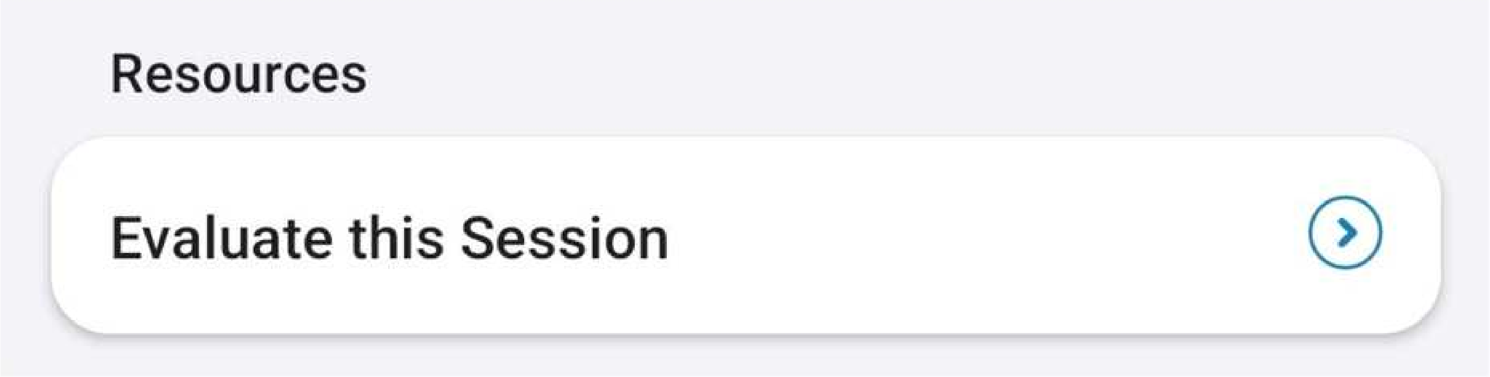
SESSION EVALUATION



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