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How the Preservation and Service Life Extension of Concrete Structures Can Contribute to Sustainability

Aamer Syed & Scott DiStefano

DENVER, COLORADO | OCTOBER 22-25, 2024

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“The built environment is responsible for about **42%** of annual global CO2 emissions

….The embodied carbon of 4 building and infastructure materials – cement, iron, steel, and aluminum – are responsible for an additional **15%** CO2 emissions annually”

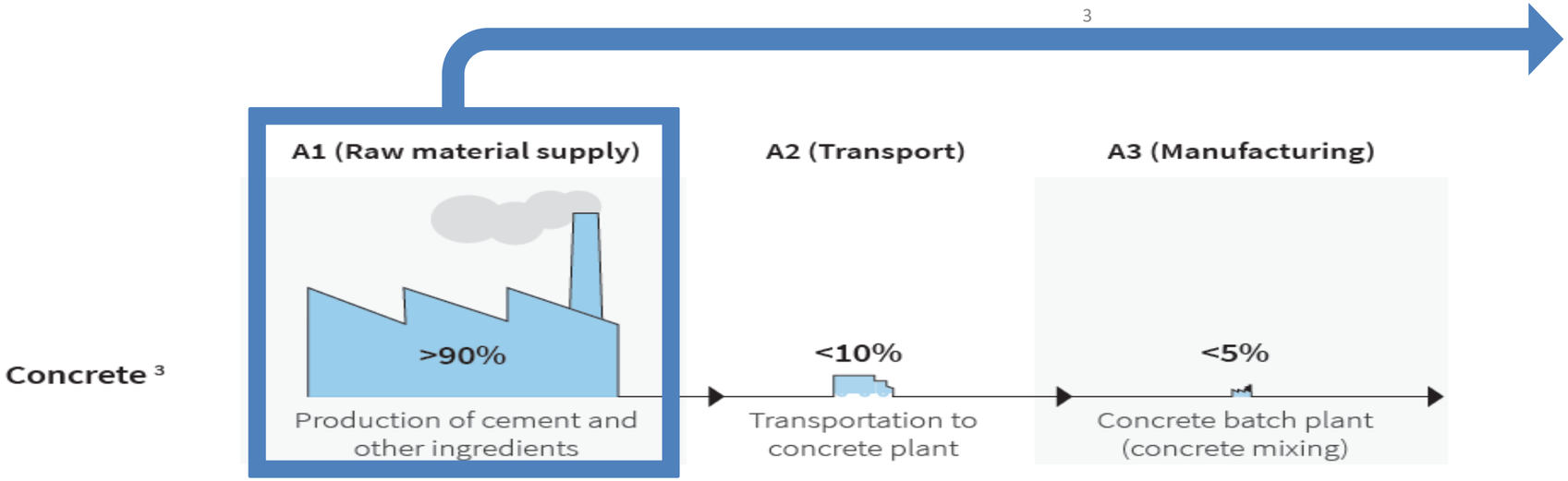
Architecture 2030

Concrete and Cement Industry

Carbon Emissions Impact

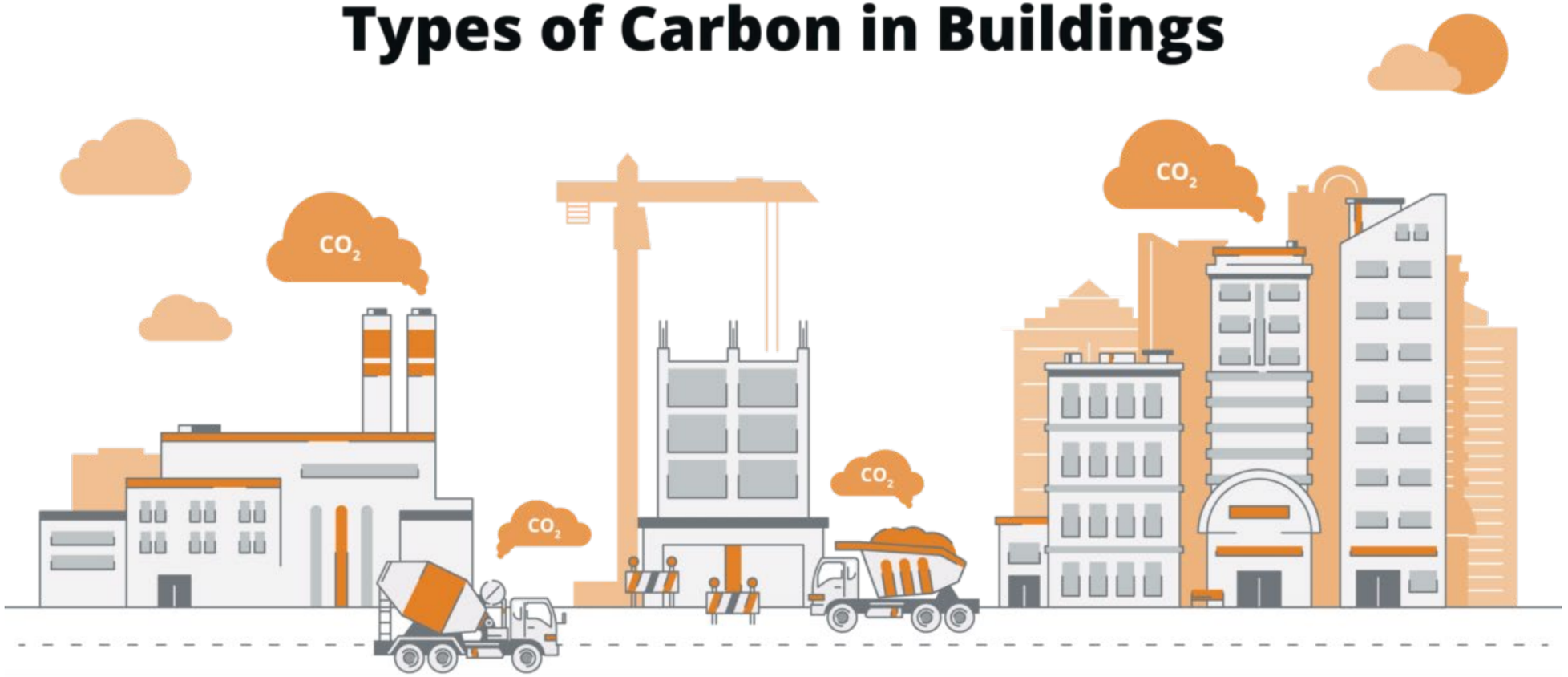
Concrete is the most-used material in the building sector

Cement production is currently the largest single industrial emitter of CO2, accounting for ~8% (2.8Gtons/y) of global CO2 emissions



Within concrete, cement accounts for the largest contribution to its GWP (global warming potential)

Types of Carbon in Buildings



Embodied Carbon
The emissions from manufacturing, transportation, and installation of building materials.

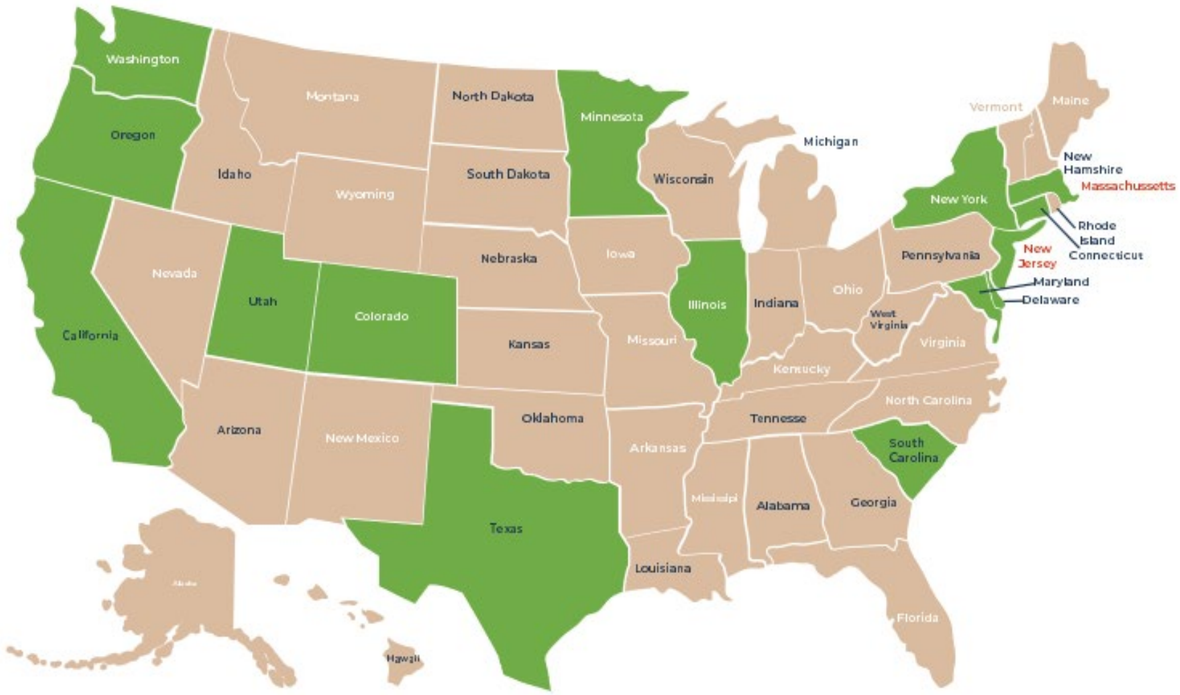
Operational Carbon
The emissions from a building's energy consumption.

Source: Carbon Leadership Forum

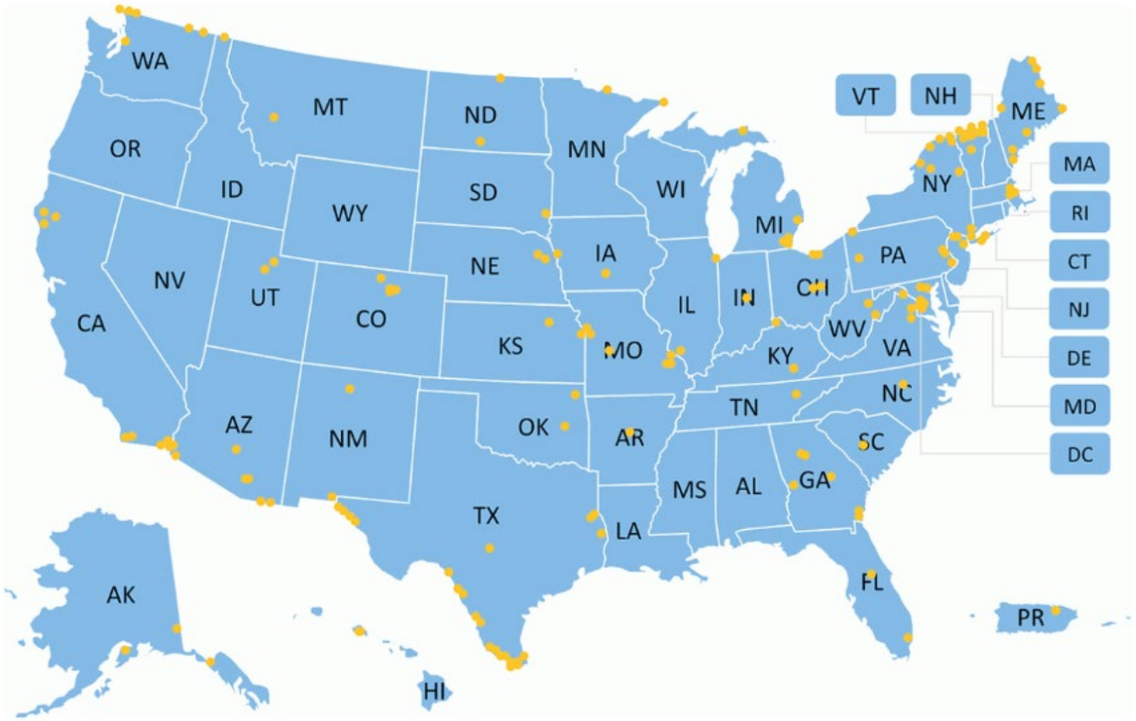
Embodied Carbon Policy

US Overview

State Embodied Carbon Policy



2024 Low Embodied Carbon Projects

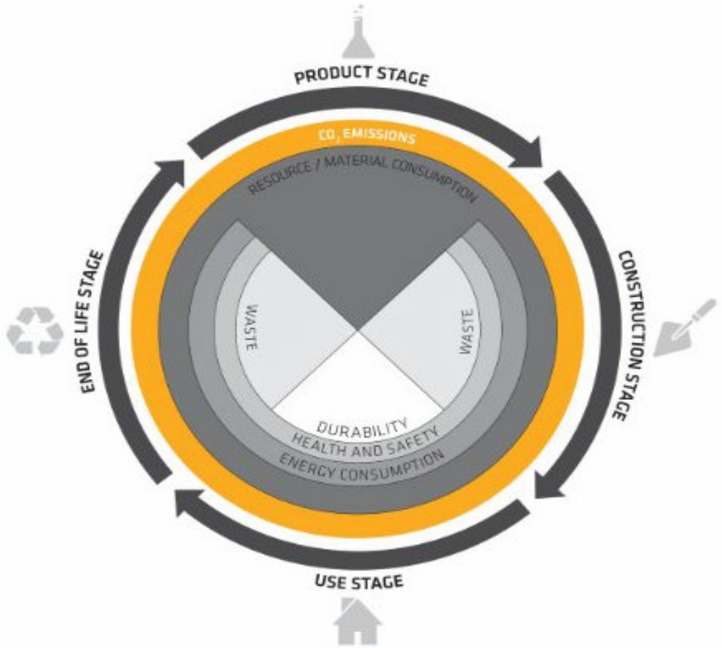


Embodied Carbon Policy

US Overview

Location	Policy	Embodied Carbon Approach
Vancouver, BC	Rezoning Requirement	Rezoning permits require a commitment to Passive House or WB LCA embodied carbon reporting.
Portland, OR	Low-Carbon Concrete Initiative	Concrete in city construction projects must meet specific GWP limits.
Oregon DOT	Department of Transportation (DOT) GHG Program	Program to reduce GHG emissions associated with concrete, asphalt pavement, and steel in DOT projects.
Marin County	Low-Carbon Concrete code	All concrete to meet specific GWP or cement limits.
California	Buy Clean California (BCCA)	State agencies, the University of CA, and CA State University systems construction projects must meet specific GWP limits for structural steel, concrete reinforcing steel, and light and medium density mineral wool board insulation.
Colorado	Buy Clean Colorado	State-funded construction projects must meet specific GWP limits for asphalt, concrete, glass, post-tension steel, concrete reinforcing steel, wood structural elements
Austin, TX	Green Building Program	The City rating system includes credits/points for WB LCA and embodied carbon reduction.
New Jersey	Port Authority of N.Y. & N.J. Low Carbon Concrete Program	Requires EPD reporting for concrete, steel, and asphalt. Require low GWP limits for concrete.
Toronto, ON	Waterfront Toronto Green Building Requirements -	Buildings can choose to use 50 percent recycled metal in steel and rebar, low-carbon concrete (with 25 percent Supplementary Cementitious Materials), or timber products certified by the Forest Stewardship Council.
New York	Low Embodied Carbon Concrete Leadership Act (LECCLA)	State-funded projects are required to procure low embodied carbon concrete.
US GSA	Low Embodied Carbon Concrete and Environmentally Preferable Asphalt Standards	Requires all GSA projects provide EPD reporting and GWP limits for concrete and improved asphalt.
CalGreen (Pending)	Carbon Reduction Regulations	All California projects over 50,000 sf can comply through building reuse, whole building LCA, or specific GWP limits for select products.
Denver Green Code	Embodied Carbon Reduction for Concrete and Steel	Requires projects using the voluntary code to meet specific GWP limits for concrete and steel products.
ASHRAE 189.1/IgCC	Global Warming Potential of Building Products	EPDs for 30 products + Product GWP limit at 125% of IW-EPD for a minimum of 10 building products and enough products to equal 15% or 20% (JO) of product costs, and products that cost 5%+ of the estimated material costs.

Shifting Towards CIRCULARITY



Contribution Towards a Circular Economy

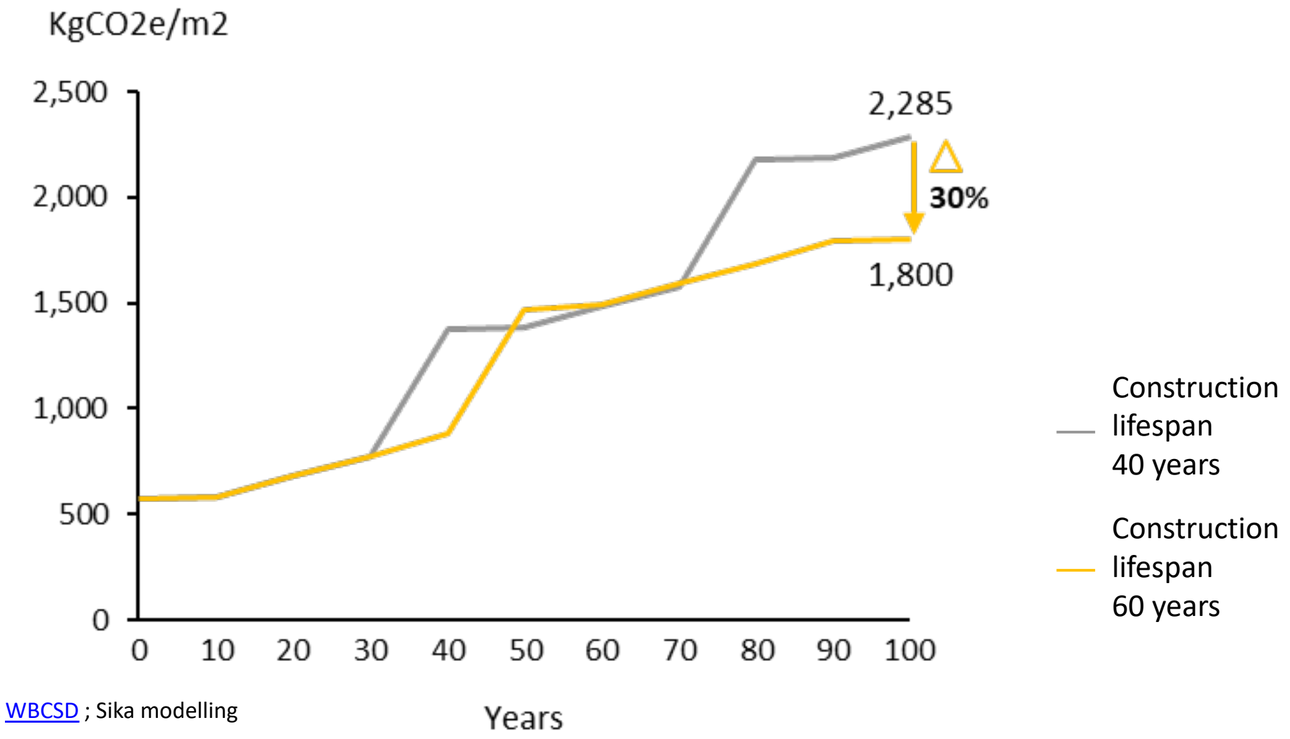
Strategies to Reduce Embodied Carbon

Build less, reuse more by extending the life of existing building and materials

Buildings With Longer Lifespan

- **According to different scenarios** (one in which the average lifespan of a residential/commercial building is 40 years and one in which the average lifespan is 60 years), it becomes clear that **the cumulative $kgCO_2$ e/m^2 decreases by 30% once the lifespan of a building is prolonged**

CUMULATIVE $kgCO_2$ e/m^2 PER LIFESPAN SCENARIO



Source: WBCSD ; Sika modelling

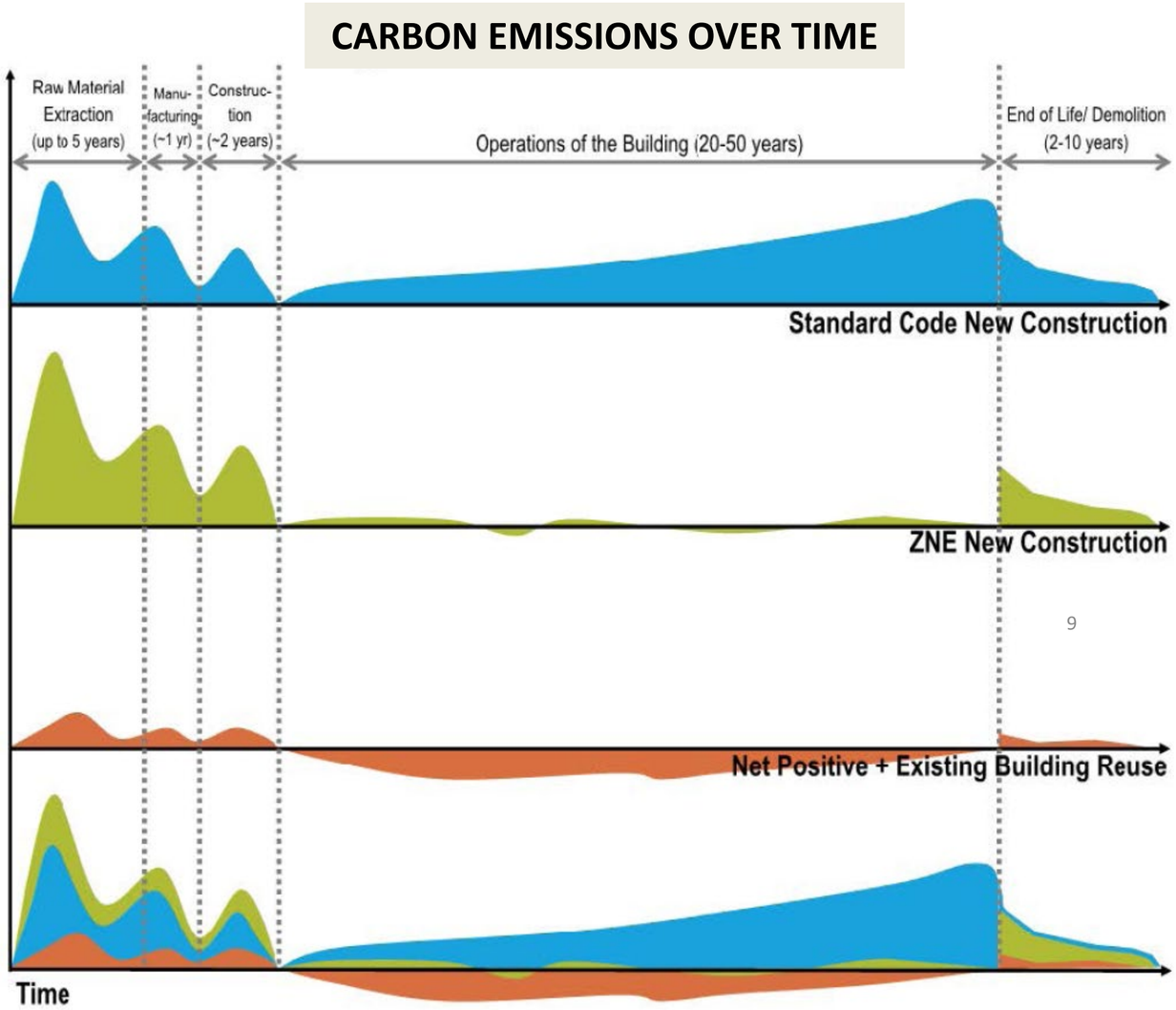
- To **generate a positive sustainability impact,** the lifecycle of buildings should be extended. This, in turn, can be achieved **through improved durability.**

30%

less CO_2 with 20 years longer lifespan of buildings

Renovation Case Study

DPR Construction, San Francisco regional office



Evaluation of total GHG emissions over time for three building types:

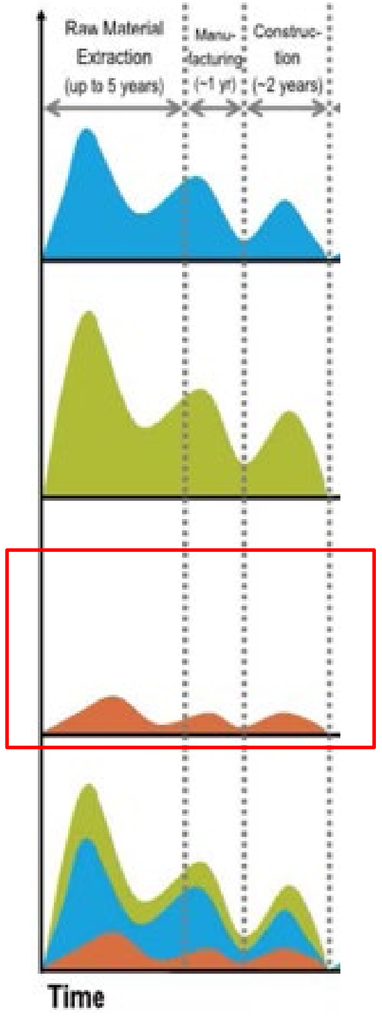
- Standard code-compliant new construction
- Zero net energy (ZNE) new construction
- Net positive existing building reuse

Reusing an existing building achieved a nearly 70% reduction in embodied carbon compared to constructing the same project from scratch

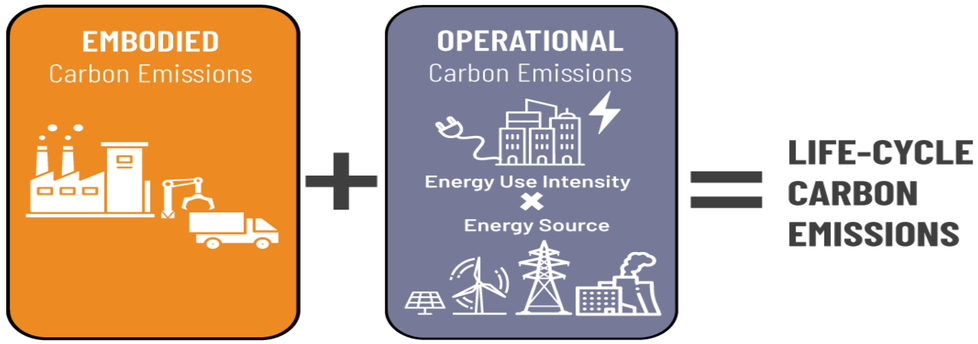
Source: *AIA - Renovate, retrofit, reuse: Uncovering the hidden value in America's existing building stock*

Renovation vs. New Construction

Embodied Carbon



- As the energy sector decarbonizes, embodied carbon will eventually account for the largest share of emissions in buildings and infrastructure
- Embodied carbon is mainly attributed to the extraction, manufacture, transportation, and assembly of building materials
- Repair and reuse of existing materials avoids emissions related to the manufacturing of new products



SMUD
MUSEUM OF SCIENCE & CURIOSITY

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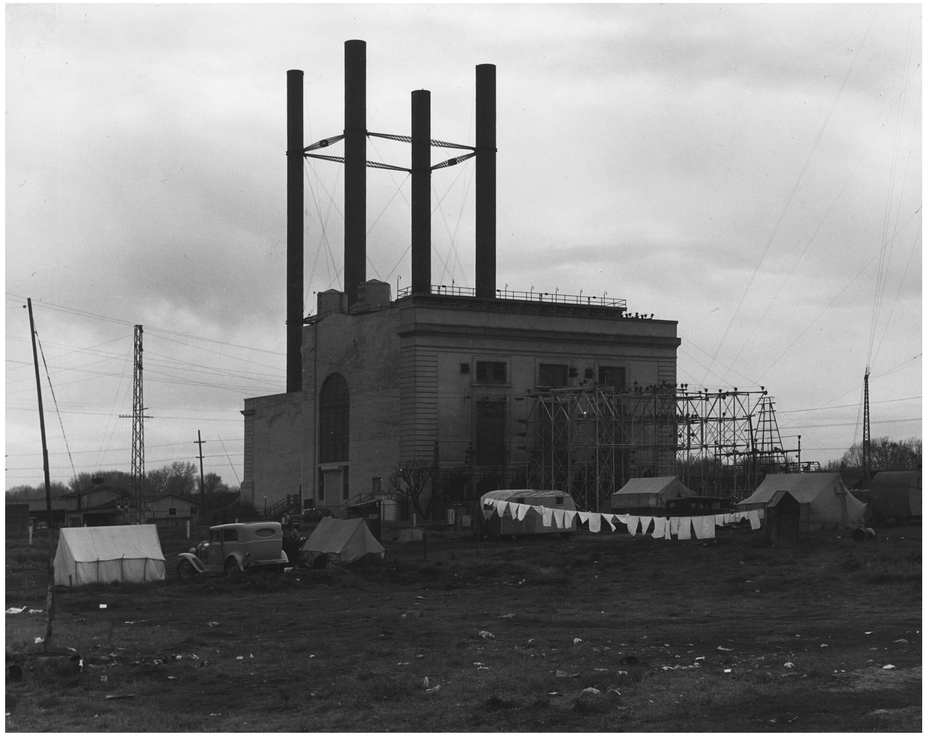
PROJECT DESCRIPTION

- Restoration and repurposing of Power Station B into SMUD Museum of Science and Curiosity (MOSAC)
- Located on Sacramento River at 400 Jibboom Street
- Original structure built in 1912 in Beaux-Arts style
- Aim: Preserve historical architecture while creating a modern science center
- Focus on public engagement and educational outreach

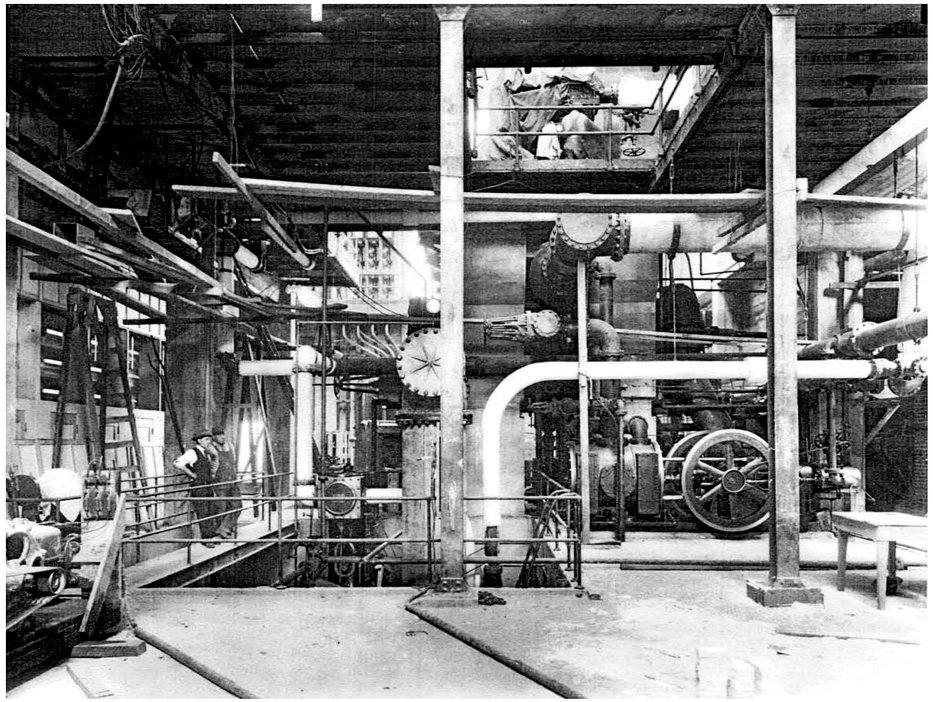
BUILDING HISTORY

- Constructed in 1912 by PG&E as Power Station B
- Produced 500 kW of electricity, expanded in the 1920s
- Largest steam power station in Northern California in its prime



BUILDING HISTORY

- Used as a test facility in the 1940s and as a tent city during the Great Depression
- Decommissioned in 1954, smoke stacks removed in 1957
- Multiple ownership changes and failed repurposing efforts from the 1960s to 2000s



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CAUSE OF DETERIORATION

- Decades of neglect and exposure to the elements
- Spalling concrete due to water infiltration
- Extensive cracks in the structure caused by age and lack of maintenance
- Loss of structural integrity after the removal of boilers and smoke stacks
- Industrial contamination, leading to hazardous waste classification

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BUILDING DETERIORATION

- Concrete walls heavily spalled and cracked
- Architectural details, such as cornices and arches, severely damaged
- Major deterioration inside and outside the building
- Classified as a high-risk hazardous site in need of cleanup
- Structural instability, requiring comprehensive reinforcement

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REPAIR AND PROTECTION OF THE BUILDING

- Structural repairs:
  - Steel exo-structure added to support aging walls
  - Selective demolition using state-of-the-art robotics
  - Complete structural retrofit with new floors and exhibit spaces
- Concrete repair:
  - Over 5,000 sq ft of spalled concrete repaired
  - 3,000 linear feet of cracks treated with urethane and epoxy
- Protection measures:
  - Corrosion-inhibiting coating applied to protect steel reinforcement
  - Anti-carbonation coating to protect against environmental degradation

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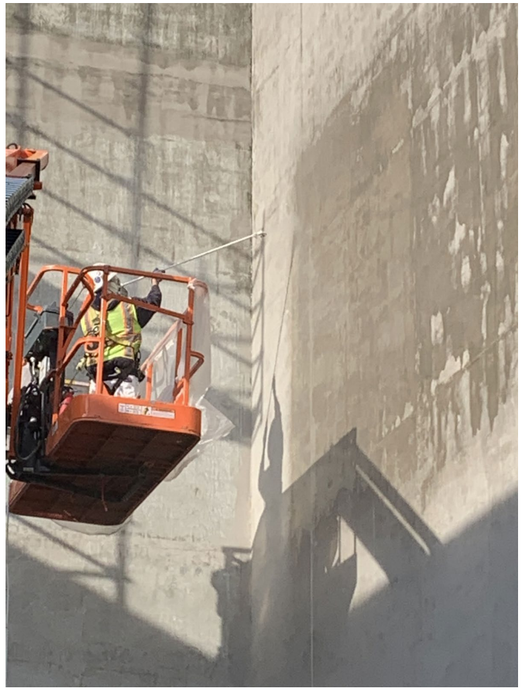
REPAIR AND PROTECTION OF THE BUILDING



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BEFORE AND AFTER

Before

After

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STRUCTURE TODAY

Photo courtesy of Caryl Communications

- Transformed into a modern museum with preserved historical elements
- New 22,000-square-foot addition:
  - Classrooms, offices, café, and planetarium
- Combination of old and new architecture, blending history and innovation
- Targeted LEED Silver certification for sustainability
- A key component of Sacramento’s Riverfront development

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IMPACT ON SUSTAINABILITY

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REUSE

1261 metric tons CO2 emission (25 years)

NEW BUILDING

1533 metric tons CO2 emission (25 years)

EMISSION SAVINGS

18% less CO2 for 25 year life span of the building

Source: caretool.org

Extension of lifecycle of structures generates positive sustainability impact! This can be achieved through durable, long-lasting repair and protection products and good workmanship.

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Aamer Syed
Vice President Infrastructure BU – Commercial Construction

EDDISON BATTERY BUILDING

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PROJECT DESCRIPTION

- The Edison Storage Battery complex
  - Former facility for alkaline storage batteries for various automotive equipment
- Ceased operating in 1965
- Designated as a historic site
- Building constructed with reinforced concrete and steel
- Repurposed to a boutique residential building in 2017
- Building renovations included
  - Façade restoration
  - Window replacement
  - Concrete repair and protection

Photo Courtesy of Prism Construction Management

BUILDING HISTORY

- Thomas Edison moved to West Orange in 1886 and build a new laboratory complex
- The battery building was constructed entirely of Reinforced Concrete
- It served as a manufacturing facility for alkaline storage batteries

BUILDING HISTORY

- The complex had 14-feet and 16-feet ceiling heights
- Thousands of openings consisting of “oversized” multi-panel industrial windows.
- Utilitarian structure
- Building sat for over 30 years, unutilized
- 2016 work began to repurpose the building to boutique residential building

CAUSE OF DETERIORATION

- Building weathered over the last 100 years with minor and poor concrete renovations
- Overall building in good structural condition
- Main affected area were the 130,000SF of facade

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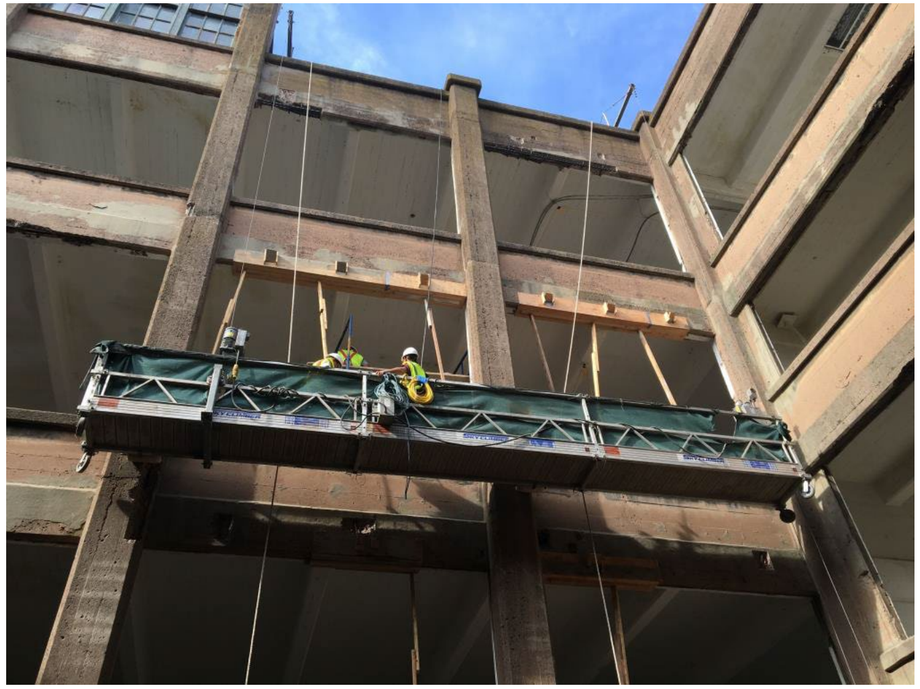
BUILDING DETERIORATION



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REPAIR AND PROTECTION OF THE BUILDING

- 11,000 SF of hand applied and form-and-pour concrete patch repairs
- Crack repairs
- 130,00SF of façade leveling material and coating
- 2,450 window replacement
- 70,000 sq.ft. TPO roof replacement

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Photo courtesy of Caryl Communications

STRUCTURE TODAY

- 330 apartments
- 18,500 square feet of retail space
- Parking structure with approximately 635 parking spaces
- Public areas including fitness lobby, swimming pool
- and sky lounge overlooking the NYC skyline

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IMPACT ON SUSTAINABILITY

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REUSE

80,000 metric tons CO2 emission (25 years)

NEW BUILDING

106,300 metric tons CO2 emission (25 years)

EMISSION SAVINGS

25% less CO2 for 25 year life span of the building

Source: caretool.org

Extension of lifecycle of structures generates positive sustainability impact! This can be achieved through durable, long-lasting repair and protection products and good workmanship.

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MONTEBELLO WATER FILTRATION PLANT

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PROJECT DESCRIPTION

- Water filtration tank built in 1915, treating 128 million gallon per day of water
- Water supplied by the Gunpowder Falls Reservoirs flows
  - Susquehanna River is utilized during droughts
- Existing structure: 8" thick concrete slab-on-ground with expansion and contraction joints on a 26' x 26' grid
- 4 basins with 2" thick concrete topping slab
- 15' tall reinforced concrete walls around the perimeter of the basins
- The sedimentation area has a revolving sweeper arm (260 feet in diameter).

BUILDING HISTORY

- Baltimore population doubled in the 1800's
- Surge of major communicable diseases
- Proper sewage disposal wand clean drinking water not available.
- To address the spread of communal diseases, water filtration was developed for large-scale water purification
- Montebello Water Filtration Plant was completed in 1915.
- Structure constructed via reinforced concrete.
- At time of construction – second largest plant in the nation

Source: Historical Society of Baltimore County

CAUSE OF DETERIORATION

- Structure had deteriorated to various levels over the years
- Conditions:
  - wide-spread cracks,
  - failed joint sealant,
  - exposed-aggregate surfaces,
  - localized spalling, and
  - topping slab delaminations.

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Saw-cutting concrete substrate

REPAIR AND PROTECTION OF THE STRUCTURE

- Basin repairs
  - concrete overlap poured in strips
  - repair of existing topping – routing and sealing cracks with epoxy
  - 5,000’ expansion joint sealed with polyurethane sealant
  - Protect the substrate with 120mils of bitumen-modified polyurethane coating to elastically bridge cracks and joints.
  - Light color coating installed as last coat to allow sediments to be seen.
- Repair of baffle walls and full equipment and hardware upgrade

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REPAIR AND PROTECTION OF THE STRUCTURE

Saw-cutting concrete substrate

SikaRepair 224 installation for concrete overlay application

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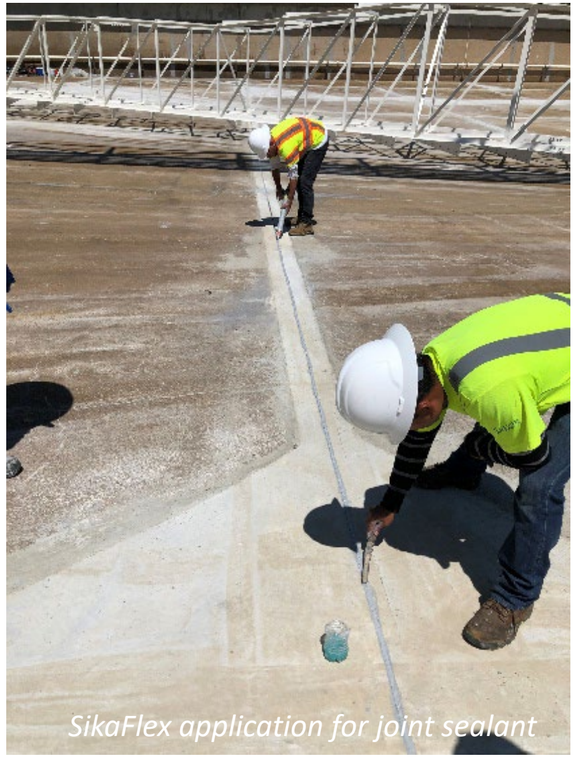
REPAIR AND PROTECTION OF THE STRUCTURE

Application of the bonding agent



SikaFlex application for joint sealant

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REPAIR AND PROTECTION OF THE STRUCTURE

Installation of SikaGard 7600

Inspection of the tank after waterproofing installation

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Photo courtesy of Caryl Communications

STRUCTURE TODAY

- The City of Baltimore operates three water filtration plants to meet current and future demands 1.8 million consumers.
- Combined, the Montebello Filtration Plants can treat up to 240 MGD

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IMPACT ON SUSTAINABILITY

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REUSE

3,119 metric tons CO2 emission (25 years)

NEW BUILDING

13,894 metric tons CO2 emission (25 years)

EMISSION SAVINGS

77% less CO2 emission for 25 year life span of the structure

Source: caretool.org

Extension of lifecycle of structures generates positive sustainability impact! This can be achieved through durable, long-lasting repair and protection products and good workmanship.

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Key Points

- Restore , Repurpose and Renew – if this is not sustainability then what is … We practice sustainability every single day.
- Concrete Rehab has to be differentiated as an industry from new construction . We need new construction, but we need to restore and repair more – and build better.
- We have not done a good job as an industry to highlight our contributions to sustainability.
- Sustainability has become the buzz word now in recent times, but we have been practicing sustainability since our inception and only getting better
- Need of the day
  - Better Image Building of our industry and our contributions
  - Government support for Repair industry just like sustainability in supported in new construction.

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Key Points

TIME

WORLD'S MOST SUSTAINABLE COMPANIES OF 2024

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TIME World's Most Sustainable Companies

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Rank	Company name	Headquarters	Website	Industry	Score
1	Schneider Electric	France	www.se.com	IT, Tech & Software	88.86
2	NEC Corp	Japan	www.nec.com	IT, Tech & Software	85.71
3	Moncler	Italy	www.moncler.com	Retail, Wholesale & Consumer Goods	85.66
4	Brambles	Australia	www.brambles.com	Transportation, Logistics & Aviation	82.98
5	Illumina	United States	www.illumina.com	Chemicals, Drugs & Biotechnology	82.63
6	SGS	Switzerland	www.sgs.com	Professional Services & Consulting	81.96
7	Sanofi	France	www.sanofi.com	Chemicals, Drugs & Biotechnology	81.22
8	NRI	Japan	www.nri.com	Professional Services & Consulting	81.03
9	Telefónica	Spain	www.telefonica.com	Telecommunication	81.02
10	Cigna	United States	www.thecignagroup.com	Banking, Insurance & Financial Services	80.52

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	Moody's	Diversified Financials	New York, New York, United States
	HP	Electronics	Palo Alto, California, United States
	Microchip Technology	Semiconductors, Electronics, Electrical Engineering	Chandler, Arizona, United States
	Colgate-Palmolive	Packaged Goods	New York, New York, United States
	Southern Company	Utilities	Atlanta, Georgia, United States
	Alliant Energy	Utilities	Madison, Wisconsin, United States
	NRG Energy	Utilities	Houston, Texas, United States
	Diversified CPC International	Chemicals	Joliet, Illinois, United States

Forbes Magazine – Net Zero Leaders List

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Parting Thought (Research Firm Zest – UK)

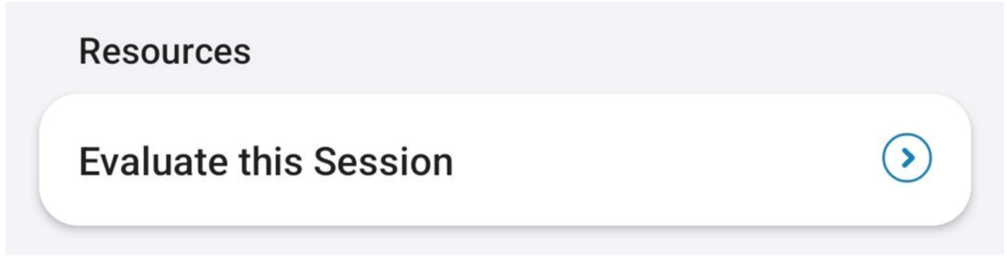
Although half (50%) of young workers now say that sustainable benefits are the most important perks to them, a third (33%) of this age group believe that their employers do not care about sustainability.

Moreover, the research reveals the worrying impact of this disconnect, particularly as younger generations increasingly enter the workforce.

Two in five (42%) aged 18-34, believe that poor sustainability initiatives have a detrimental impact on their morale at work. This not only leaves existing employees demotivated, but businesses at risk of failing to attract fresh talent.

A PERSONAL STORY , CHANGE IS POSSIBLE – SHEHREEN SYED

SESSION EVALUATION



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