The Role of Concrete in Carbon Neutrality

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Sustainable Structure Webinar Series

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1

Learning Objectives

- Describe carbon neutrality, sustainability, and resilience in the context of the concrete industry.
- Identify ways the concrete industry can contribute to a goal of carbon neutrality for concrete structures.
- Describe the difference between prescriptive and performance-based requirements in "green" concrete codes.
- Summarize the current status of the concrete industry in applying low carbon solutions.

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Overview

Carbon emissions
    cement
    concrete
    infrastructure
The bigger picture
    sustainable concrete
    resilient concrete
Legislation
Impact vs greenwashing

3

A Global Movement

- Paris Agreement
  - Targets limiting global warming to 1.5 C
- US goal is to reduce emissions by around 50% below 2005 levels by 2023
  - 100% carbon pollution-free electricity by 2035
  - Net zero (all greenhouse gases) by 2050
  - Some companies targeting net zero by 2030

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4

Definitions

- Carbon Neutral
  A neutral effect of CO_2 on the atmosphere
- Net Zero
  A neutral effect of <u>all</u> greenhouse gases on the atmosphere
- Global Warming Potential (GWP)
  A way to compare the long-term effect of different gases

Overview of U.S. Greenhouse Gas Emissions in 2020

Nitrous Oxide
7%

Fluorinated Gases
3%

Methane
11%

Carbon Dioxide
79%

U.S. Environmental Protection Agency (2022). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020

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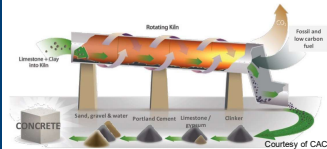
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Carbon Neutral (Portland cement example)

CO_2 emissions

Energy from fossil fuels | Calcination of limestone | CS and offsets required for Carbon Neutral

CO_2 emissions

Clean energy | Calcination of limestone | CS and offsets required for Carbon Neutral

NET ZERO

Clean energy | Alternative materials for cement production

Goal

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Carbon Emissions from Cement

- 51 Billion Tons of Carbon is released into the atmosphere annually
  31% - how we make things (cement, steel, plastic)
- 5-8% of global carbon emissions are associated with cement and concrete production
  ~1.25% US carbon emissions come from manufacturing of cement
- About 60% of cement emissions are from calcination of the limestone

Courtesy of CAC

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Concrete vs Cement: Spread the word

Cement

Concrete (and masonry, grout, etc.)

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8

The importance of the full picture for Carbon Emissions

Policies, Codes, Standards

We are getting this → GWP or cement limits
prescriptive

Cradle-to-gate concrete

Cradle-to-grave concrete

We need this →

Life Cycle

Goal

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9

Tools and Acronyms

- **LCA** (Life Cycle Assessment)
  - Standardized method (ISO 14040 and ISO 14044) looking at a broad range of environmental impacts over a product/process life cycle
  - A form of Life Cycle Analysis specific to environmental impacts (not only carbon emissions)
- **PCR** (Product Category Rules)
  - Rules for a category of products with equivalent functions
  - Sets rules for the resulting EPD
- **EPD** (Environmental Product Declaration)
  - Comes from an LCA
  - Simplified summary using instructions from the PCR

LCA ✚ PCR ＝ EPD

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What do we have right now?

- Cement
  - Alternative fuels
  - Energy efficiency
  - Blended cements
  - Type 1L cement (portland limestone cement)
  - Slag cement
  - LC3 (limestone calcined clay cements)

- Concrete
  - Partial cement replacement (SCMs)
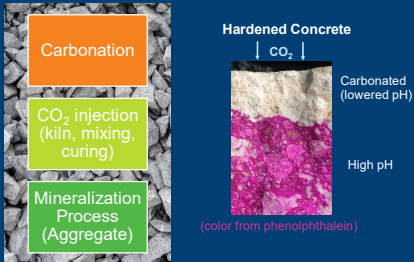 - High volume SCMs
  - Design optimization
  - Recycled aggregates

  Many alternative cements at varying stages of readiness

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Carbon Capture, Utilization & Sequestration (CCUS)

CCUS is part of the solution, but reducing initial carbon must be the priority

Carbonation

CO_2 injection (kiln, mixing, curing)

Mineralization Process (Aggregate)

Hardened Concrete
$\downarrow CO_2 \downarrow$

Carbonated (lowered pH)

High pH

(color from phenolphthalein)

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12

Slide 13

THE BIGGER PICTURE

Concrete in use

- Sustainable
- Resilient

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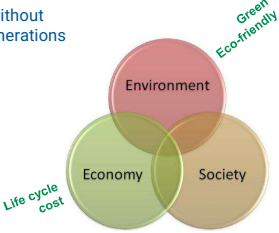neu — ACI Center of Excellence for Carbon Neutral Concrete — 13

13

Slide 14

Sustainable (commonly used definition)

"…meeting the needs of the present without compromising the ability of future generations to meet their own needs."

*Brundtland Commission
United Nations, 1987*

Low carbon concrete is just one slice of sustainability

Green Eco-friendly

Environment

Economy   Society

Life cycle cost

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14

Slide 15

United Nations

SUSTAINABLE DEVELOPMENT GOALS — 17 GOALS TO TRANSFORM OUR WORLD

1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
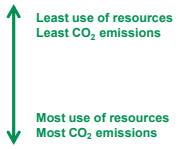17 PARTNERSHIPS FOR THE GOALS

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15

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Depletion of Natural Resources

- **Reduce**
  Minimize waste through reduction of resource use
- **Reuse**
  Using again in basically the same form
- **Recycle**
  Breaking down the material into components to form a new component or use
- **New Construction**

Least use of resources
Least CO_2 emissions

Most use of resources
Most CO_2 emissions

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Some Sustainable Material Considerations (Beyond the Gate)

- Material and components (including sourcing, production energy, renewable, toxicity, etc.)
- Benefits in use (energy savings, heat island reduction, VOC reduction, daylighting, etc.)
- Design optimization
- Transportation
- Construction
- Durability and resilience
- End of life or cradle to cradle opportunities

Environment
Economy Society

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Resilience (and the cost of disaster)

An ability to recover from or adjust easily to adversity or change

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Resilience and Sustainability

Sustainable

Ex: solar with storage

Resilient

Ex: renewable energy

Ex: gas generator with tanks of stored fuel

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19

19

Codes, Standards and Specifications

- Model Building Codes
  - o IBC (International Building Code)
    - Proposal S178 included CO2e limits (disapproved)
  - o IEBC (International Existing Building Code)
  - o IgCC (International Green Construction Code)
    - Includes ANSI/ASHRAE/USGBC/IES 189.1 Standard for the Design of High-Performance Green Buildings (Except Low-Rise Residential Buildings)
- Other examples: ICC 700 Nat'l Green Building Standard, ASCE/COS 73-xx Standard Req. for Sust. Infrastructure

IgCC 2021

Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings

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20

20

Adoption (State and Local Jurisdictions)

Mandatory and non-mandatory

- Current proposals have focused on GWP or cement content based on strength
- Some weighted approaches
- Some voluntary LCA approaches
- Many proposals in process or coming soon all across the U.S.

- Example: CalGreen (California Green Building Standards Code)

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21

21

ACI 323 Low-Carbon Concrete Code

- To address limitations with current approaches
  - Strength based does not incentivize best long-term approach for lowered CO_2
  - One-size-fits-all approach misses regionality
  - Direct line to zero from current to 2050 problematic
- Current ACI 323 thinking (in progress)
  - Common model (unified approach) for concrete
  - Straightforward
  - Address material variation by region
  - Move away from strength basis

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22

Some thoughts about greenwashing

Suspect	Good signs
• Vague claims • Fluffy words/images • Misleading logos • Lack of applicable data • Clean product from dirty process	• Apples to apples data • Clear communication • Transparency (pros and cons) • Meaningful contribution

GREEN CONCRETE WORLDWIDE

Magic Gray Powder

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23

Some thoughts about greenwashing

Suspect	Good signs
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FAKE GREEN CONCRETE WORLDWIDE

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Some non-concrete examples

Watch for tradeoffs:

Reduce → Best
Reuse → Better
Recycle → Good

CFC FREE

The Eggloo

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25

Other considerations

- Has the product been used at scale?
- Is it available in large enough quantities?
- Beyond the environmental claims, how are other properties changed (and have they been tested)?
- Does it require special equipment to place, test, cure, etc?
- Is it regionally available?

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Webinars
FAQs
Electronic newsletter
Guides

The Sustainable Concrete Guide

The Sustainable Concrete Guide

The Sustainable Concrete Guide:

Low Carbon Materials and Technologies (2023)

NEW PRODUCT VALIDATION PROGRAM

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27

What's coming next?

- Legislation with Global Warming Potential limits tracking to zero with time
- Large scale implementation of current sustainable practices
- Owners targeting carbon neutrality goals
- Significant innovations in materials and processes

ACI Codes in progress:
ACI 318-25 Building Code Requirements for Structural Concrete with Appendix on Sustainability
ACI 323-25 Low Carbon Concrete Code

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28

28

Summary

- *Reducing CO$_2$ emissions from the cement and concrete industry are critical but are only one slice of the bigger sustainable and resilient concrete picture.*
- The sustainability movement is here to stay
- Resilience is critical for long term stability
- We need to move quickly to lead the effort the before policy makers do it for us

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29

29

Thank you!

Questions?

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30

30