The Drive Toward Reducing Carbon in Concrete Construction
Speakers

Donna Laquidara-Carr, PhD, LEED AP
Industry Insights Research Director
Dodge Construction Network

Allison Palmer
Senior Manager, Strategic Business
CarbonCure Technologies
Why Address Embodied Carbon?

The Importance of Concrete in Reducing Embodied Carbon

Where We Are Now

Drivers for Increasing Reductions

Challenges

Advancements in Concrete
Building Sector share of total GHG emissions:
- 57% indirect emissions from offsite generation of electricity and heat
- 24% direct emissions produced onsite
- 18% embodied emissions

Need further gains: in most regions, efficiency improvements: have been matched by growth in floor area per capita.

“Well-designed and effectively implemented mitigation actions in the building sector have significant potential for achieving the UN Sustainable Development Goals.”
Start treating carbon accounting the same way you treat your financial accounting. You need to know [your entire] footprint and what you can do about it.

Cristina Gamboa, CEO, World Green Building Council
AGENDA

- Why Address Embodied Carbon?
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- Challenges
- Advancements in Concrete
Cement makes up only 12% of the weight of concrete. 

But is responsible for 95% of concrete’s carbon footprint.
Cement Manufacturing Process

CaCO₃ (Limestone (Calcium carbonate)) + Heat (+) calcination reaction → CO₂ → CaO → Cement
Cement Manufacturing Process

1 ton cement = 0.922 ton CO$_2$
(2021 EPD for US Portland Cement)

CaCO$_3$ (Limestone (Calcium carbonate)) + Heat (+) calcination reaction → CaO

CaO → Cement
Concrete is the most abundant human-made material in the world.

As a result, cement production creates \(~7\%\) of the world’s \(\text{CO}_2\) emissions and is one of the largest contributors to embodied carbon in the built environment.
Concrete Made At Unparalleled Scale

Source: “27 Materials on Which Industrialized Society Depends”
Cement Demand Projection

Cement demand expected to grow 12 to 23% by 2050.

-IEA, Cement Sustainability Initiative
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Online Study Conducted Spring 2022

Requirements to participate:

Had to be involved with or have influence over the specification or purchase of concrete for projects.

- 45 Architects
- 43 Structural Engineers
- 45 Contractors
Current Approach to Tracking and Reducing Embodied Carbon

58%

Share of Respondents Who Track Embodied Carbon on at Least Some of Their Projects

<table>
<thead>
<tr>
<th>Professionals</th>
<th>Track on All</th>
<th>Track on Most</th>
<th>Track on At Least Some</th>
<th>Not Yet Tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architects</td>
<td>16%</td>
<td>4%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Engineers</td>
<td>21%</td>
<td>30%</td>
<td>2%</td>
<td>7%</td>
</tr>
<tr>
<td>Contractors</td>
<td>7%</td>
<td>22%</td>
<td>27%</td>
<td>13%</td>
</tr>
</tbody>
</table>

- We track the embodied carbon on all of our building projects and are actively seeking to reduce it.
- We track the embodied carbon on most of our building projects and are actively seeking to reduce it.
- We track the embodied carbon on at least some of our building projects and are actively seeking to reduce it.
- We are tracking embodied carbon on at least some of our projects, but are not yet seeking to reduce it.
Means of Measuring Embodied Carbon

- Environmental Product Declarations (EPDs): 71%
- Conduct Project Lifecycle Analysis: 64%
- Digital Tool Designed to Determine Embodied Carbon: 58%
Lifecycle Analysis

Use of Lifecycle Analysis
(By Green Engagement)

Dodge Data & Analytics: 2022

- Highly Involved in Green Building: 71% Share, 64% Average
- Formal Commitment to Reduce Carbon Emissions: 84% Share, 44% Average
- Staff Dedicated to Green Activity: 90% Share, 43% Average
- Track Embodied Carbon: 52% Share, 43% Average
Environmental Product Declarations

EPDs use consistent measurements for easy & objective comparison of products in same category

Environmental Facts
Functional unit = 1 yd$^3$ of concrete

<table>
<thead>
<tr>
<th>Environmental Impact</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Energy Demand (BTU)</td>
<td>$9.3 \times 10^5$</td>
</tr>
<tr>
<td>Global Warming Potential (lb CO$_2$ eq)</td>
<td>360</td>
</tr>
<tr>
<td>Acidification Potential (lb H+ eq)</td>
<td>40</td>
</tr>
<tr>
<td>Eutrophication Potential (lb N eq)</td>
<td>0.4</td>
</tr>
<tr>
<td>Ozone Depletion Potential (lb CFC-11 eq)</td>
<td>$1.98 \times 10^{-5}$</td>
</tr>
<tr>
<td>Smog Potential (lb O$_3$ eq)</td>
<td>21</td>
</tr>
</tbody>
</table>
Prove how your concrete is different

CarbonCure Express EPD

**Easy as 1,2,3**
- CarbonCure does all the heavy lifting
- No headaches
- CarbonCure provides the guidance and expertise to create the LCA and EPD
- Low time investment

**Straightforward Cost**
- Less upfront costs
- Fixed fee per plant
- Unlimited EPDs per plant

**High-Quality**
- Product-specific EPDs
- Digital integration allows for fast and accurate EPDs using real data
How CarbonCure Express EPD is Different

1. **Tell Us About Your Mixes**: We need to know about the raw materials that go into your mixes.
2. **Tell Us About Your Plant**: Help us learn more about your suppliers and ancillary materials.

And that’s it! We take care of the rest.
Use of EPDs

Use Environmental Product Declarations (All Respondents)

- Use EPDs: 89%
- Do Not Use EPDs: 11%

Frequency of Use of EPDs (According to Those Using Them)

- Use EPDs on All Projects, Whenever Available: 49%
- Use EPDs Only on Projects With Specific Sustainability Goals: 36%
- Use EPDs Only When Required to by Other Stakeholders: 15%
Use of EPDs

By Type of Company

- Architects: 22%
- Engineers: 56%
- Contractors: 54%

Frequency of Use of EPDs
(According to Those Using Them)

- Use EPDs on All Projects, Whenever Available: 49%

Dodge Data & Analytics, 2022
Frequency That Practitioners Request EPDs on All Projects

By Type of Company
- Architects: 9%
- Engineers: 21%
- Contractors: 39%

By Involvement in Green Projects
- Low: 13%
- Moderate: 16%
- High: 45%
Increased Use of EPDs in the Last Year

- Architects: 33%
- Engineers: 66%
- Contractors: 71%
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Owners Driving Increased Engagement

Frequency of Client Requests for Reducing Embodied Carbon

Dodge Data & Analytics, 2022

- Architects
  - Never: 49%
  - Infrequently (Fewer Than 25% of Projects): 40%
  - Somewhat Frequently (25% to 49% of Projects): 7%
  - Frequently (50% of Projects or More): 4%

- Engineers
  - Never: 2%
  - Infrequently (Fewer Than 25% of Projects): 39%
  - Somewhat Frequently (25% to 49% of Projects): 26%
  - Frequently (50% of Projects or More): 33%

- Contractors
  - Never: 9%
  - Infrequently (Fewer Than 25% of Projects): 38%
  - Somewhat Frequently (25% to 49% of Projects): 31%
  - Frequently (50% of Projects or More): 22%
Owners Driving Increased Engagement

**Frequency of Clients Asking for EPDs**

- 41% for All
- 27% for Most
- 17% for Some
- 12% for Very Few
- 3% for None/Not Sure

**Most/All Clients Ask for EPDs**

- 63% for Architects
- 64% for Engineers
- 7% for Contractors

Dodge Data & Analytics, 2022
Owners Driving Increased Engagement

Involved in Projects With Owners/Investors With Specific ESG Commitments

Dodge Data & Analytics, 2022

- Increase in the Number of Owners With Commitments in the Past Year
- Unsure of Owner Commitments/Unfamiliar With ESG

<table>
<thead>
<tr>
<th>Professionals</th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architects</td>
<td>18%</td>
<td>33%</td>
<td>49%</td>
</tr>
<tr>
<td>Engineers</td>
<td>65%</td>
<td>21%</td>
<td>14%</td>
</tr>
<tr>
<td>Contractors</td>
<td>51%</td>
<td>29%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Reasons That Practitioners Currently Take Embodied Into Consideration at Project Start

- To Meet Company’s Green Goals: 58%
- To Influence Wider Industry Adoption of Considering Embodied Carbon: 51%
- To Gain Experience for Upcoming Policy and Regulatory Mandates: 48%
- To Meet Clients’ Goals on Projects: 46%
- Right Thing to Do: 43%
Importance of Integrating Reduction of Embodied Carbon Into Green Building Projects in the Next Five Years

Vital Aspect of Future Green Projects

- Vital Aspect of Future Green Projects: 50%
- Only Important for Those Doing Intensive Green Building Projects: 42%
- Will Not Have an Important Role: 8%

Vital Aspect of Future Green Projects

- Architects: 42%
- Engineers: 61%
- Contractors: 49%
Global CO₂ Challenge

Global temperature projections for various scenarios

- **RCP8.5**
  - Business-as-usual
  - 2.2 trillion tons carbon

- **RCP6.0**
  - Emissions peak 2080
  - 1.6 trillion tons carbon

- **RCP4.5**
  - Emissions peak 2040-50
  - 1.3 trillion tons carbon

- **RCP2.6 (1.5°C)**
  - 0.53 trillion tons carbon
  - Zero CO₂ emissions ~2050

Source: Reproduced with permission from Architecture 2030; Adapted from IPCC Fifth Assessment Report, 2013. Representative Concentration Pathways (RCP), temperature projections for SRES scenarios and the RCPs.
The Embodied Carbon Challenge

A multi-disciplinary challenge to achieve net zero embodied carbon by 2050

**The 2030 Challenge for Embodied Carbon**

*Buildings, Infrastructure, and Materials*

- Reduction
- Embodied Carbon Emissions

<table>
<thead>
<tr>
<th>Year</th>
<th>Reduction</th>
<th>Embodied Carbon Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>2030</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>2040</td>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td>2050</td>
<td>100%</td>
<td>Zero Embodied Carbon Emissions</td>
</tr>
</tbody>
</table>

**Mission alignment with:**

- CLF Carbon Leadership Forum
- SEI ASCE
- Architecture 2030
- C40 CITIES
- World Green Building Council

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Why Address Embodied Carbon?

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## Top Reasons That Embodied Carbon Is NOT Taken Into Consideration at Project Start

**Architects**
- Not a priority for most clients (71%)
- Concerns about increased cost (49%)
- Lack of knowledge of how to measure (44%)

**Engineers**
- Not a priority for most clients (37%)
- Concerns about increased cost (37%)
- Concerns about schedule impacts (33%)

**Contractors**
- Concerns about increased cost (58%)
- Lack of knowledge of how to measure (33%)
- Not a priority for most clients (31%)
Top Reasons That Embodied Carbon Is NOT Taken Into Consideration at Project Start

- Concerns About Increased Cost: 45% (Has Formal Carbon Commitment) vs. 50% (Does Not Have Formal Carbon Commitment)
- Concerns About Schedule Impacts: 17% (Has Formal Carbon Commitment) vs. 34% (Does Not Have Formal Carbon Commitment)
- Lack of Knowledge of How to Measure: 33% (Has Formal Carbon Commitment) vs. 42% (Does Not Have Formal Carbon Commitment)
- Not a Priority for Most Clients: 31% (Has Formal Carbon Commitment) vs. 70% (Does Not Have Formal Carbon Commitment)
Reasons That Practitioners Currently Do NOT Conduct a Lifecycle Analysis on Their Projects

- Not Required by Clients: 82%
- Not Familiar With Doing One: 15%
- Do Not Seek Green Certification on Projects: 12%
- Too Difficult to Conduct: 6%
- Do Not Think It Is Reliable: 3%
Importance of Reducing Embodied Carbon of Concrete to Overall Embodied Carbon Reduction on Projects

- **Very High Impact**: It has/would have the largest impact of any single material on my projects
  - Architects: 13%
  - Engineers: 21%
  - Contractors: 22%

- **High Impact**: It has been/would be an important part of an overall strategy to reduce embodied carbon on projects
  - Architects: 31%
  - Engineers: 51%
  - Contractors: 63%

- **Moderate Impact**: It has been/would be a moderate part of an overall strategy to reduce embodied carbon on projects
  - Architects: 14%
  - Engineers: 16%
  - Contractors: 45%

- **Low/No Impact**: It is not/would not be an important part of an overall strategy to reduce embodied carbon on projects
  - Architects: 2%
  - Engineers: 11%
  - Contractors: 11%
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Aware of Concrete Products or Companies That Can Reduce the Level of Embodied Carbon

- Architects: 31%
- Engineers: 65%
- Contractors: 49%
CarbonCure’s Solution for Embodied Carbon

- CarbonCure’s CO₂ mineralization technologies offer a proven solution for reducing embodied carbon **today**
- The tech beneficially repurposes CO₂ to produce the same high quality concrete but with a lower carbon footprint.
Concrete Manufacturing Process

\[ \text{CaCO}_3 \xrightarrow{\text{Heat (+) calcination reaction}} \text{CO}_2 \]

\[ \text{CaCO}_3 \rightarrow \text{Limestone (Calcium carbonate)} \]

\[ \text{CaO} \rightarrow \text{Cement} \]

Add aggregate, water & admixtures

Concrete
Converting CO$_2$ to a Mineral

**CaCO$_3$** (Limestone (Calcium carbonate)) → Heat (+) calcination reaction → **CO$_2$** → **CaCO$_3$** (Mineralized Concrete)

Add aggregate, water & admixtures → **Cement** → **CaO** → **CaCO$_3$**
CO$_2$ Injection
New Emphasis on Embodied Carbon

Green buildings certification systems now address embodied carbon

LEED BD+C: New Construction | v4.1 - LEED v4.1

Building Life-Cycle Impact Reduction

Possible 5 points

- **2 points**
  Demonstrated impact reduction of at least 5% in global warming potential (GWP) and 2 other impact categories

- **3 points**
  Demonstrated impact reduction of at least 10% in global warming potential and 2 other impact categories

- **4 points**
  Demonstrated impact reduction of 20% in global warming potential, at least 10% in 2 other impact categories, and building reuse and/or use of salvaged materials

Materials & Resources

Focuses on minimizing embodied environmental impacts to support a life cycle approach that improves performance

Option 4: Whole Building Life Cycle Assessment (1-4 points)

Conduct a life cycle assessment and show a 10% impact reduction in embodied CO$_2$ emissions + 2 other impact categories shown on an environmental product declaration
• 48% of emissions reductions must come from carbon capture and utilization strategies
• 37% of reductions must come from reduced clinker to cement ratios
Key Takeaways & Questions
Thank you