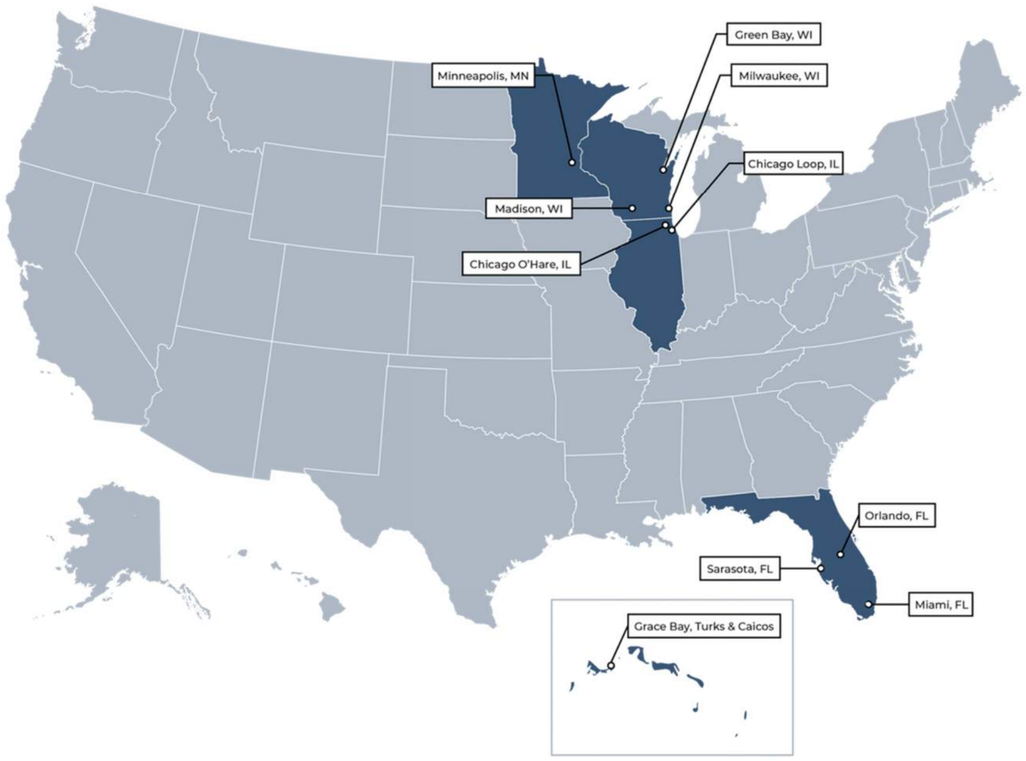
EMBODIED CARBON ACTION PLAN (ECAP)

March 2026

"OUR CORE PURPOSE IS TO
IMPROVE THE PHYSICAL ENVIRONMENT
FOR THE BENEFIT OF SOCIETY
IN A SUSTAINABLE MANNER."

INTRODUCTION



GRAEF is an ENR Top 500 planning, design, and engineering firm with ten offices located in Wisconsin, Minnesota, Illinois, Florida, and the Turks and Caicos Islands. Established in 1961 with deep hometown roots, GRAEF has grown to become a prominent multi-disciplinary firm.

As a team of passionate, innovative professionals, we support the industry vision that structural engineers shall understand, reduce, and ultimately eliminate embodied carbon in our projects by 2050.

As a participant in the SE 2050 Commitment Program, we are collaborating internally and externally to educate our staff and our clients and advocate internally and externally to reduce embodied carbon in our work. We aim to do our part to contribute to an industry culture that promotes sustainable design.

OUR CORE VALUES

LOYALTY

TO OUR EMPLOYEES

SERVICE

SUPERIOR SERVICE TO OUR CLIENTS

QUALITY

IN ALL OF THE WORK WE DO

INTEGRITY

IN ALL OF OUR BUSINESS ACTIVITIES

GRAEF FOUNDERS, 1961

SUSTAINABILITY LEADERSHIP

Meet our Structural Sustainability Champions

GEORGE CARR PE

Structural Engineer

MILWAUKEE, WI

SE 2050 Embodied Carbon Champion

JASON GROSS PE SE

Structural Engineer & Project Manager

MILWAUKEE, WI

MEGHANN RIEDNER PE SE

Structural Engineer & Project Manager

MADISON, WI

JUSTIN BITTENBENDER PE

Structural Engineer & Project Manager

MILWAUKEE, WI

EDUCATION

Embedded within the core values of GRAEF is the firm's commitment to quality work performed with integrity. Taking ownership of our projects and the legacy that this work leaves behind is paramount to upholding our integrity. Underpinning all the work we perform is our dedication to the betterment of public health and safety; we understand that reducing embodied carbon is an important public health issue. Evaluating the role that engineers play in the global initiative to reduce carbon emissions is a health and safety commitment in which we must participate.

Each region of the nation has unique practices for meeting sustainability goals and sharing information across all offices will encourage novel approaches to the most challenging projects. By engaging sustainability champions across our offices, we can ensure a cohesive and consistent approach to carbon reduction. Reduction strategies and best practices incorporated into specifications will be based on available online resources and feedback we have received from local concrete suppliers, steel fabricators and general contractors about material availability and industry practices.

In order to engrain embodied carbon solutions into our design processes, our education initiatives utilize the existing collaborative infrastructure within the firm. We strive to share intra-office knowledge and resources with all team members to encourage and support engineers in understanding their role in reducing embodied carbon. The Structural Sustainability Committee (SSC) is one of several groups working to update and develop GRAEF's technical standards. As part of this effort, the SSC will be working with other structural engineering technical committees to update GRAEF's specifications to include embodied carbon reduction strategies and goals.

The SSC is developing educational resources for both structural engineers and project managers throughout the company about embodied carbon reduction strategies. We are currently training engineers in multiple offices to use Tally to run LCAs and will be evaluating additional software for measuring and tracking embodied carbon, to determine the best option to integrate into our design process. A playbook for project managers is being developed with recommendations for discussing embodied carbon reduction with owners and construction teams. The SSC plans to present project LCA data during our bi-monthly structural technical meetings, so that we can start a company-wide, ongoing conversation about how current designs compare to national and/or regional benchmarks, and the most effective embodied carbon reduction strategies.

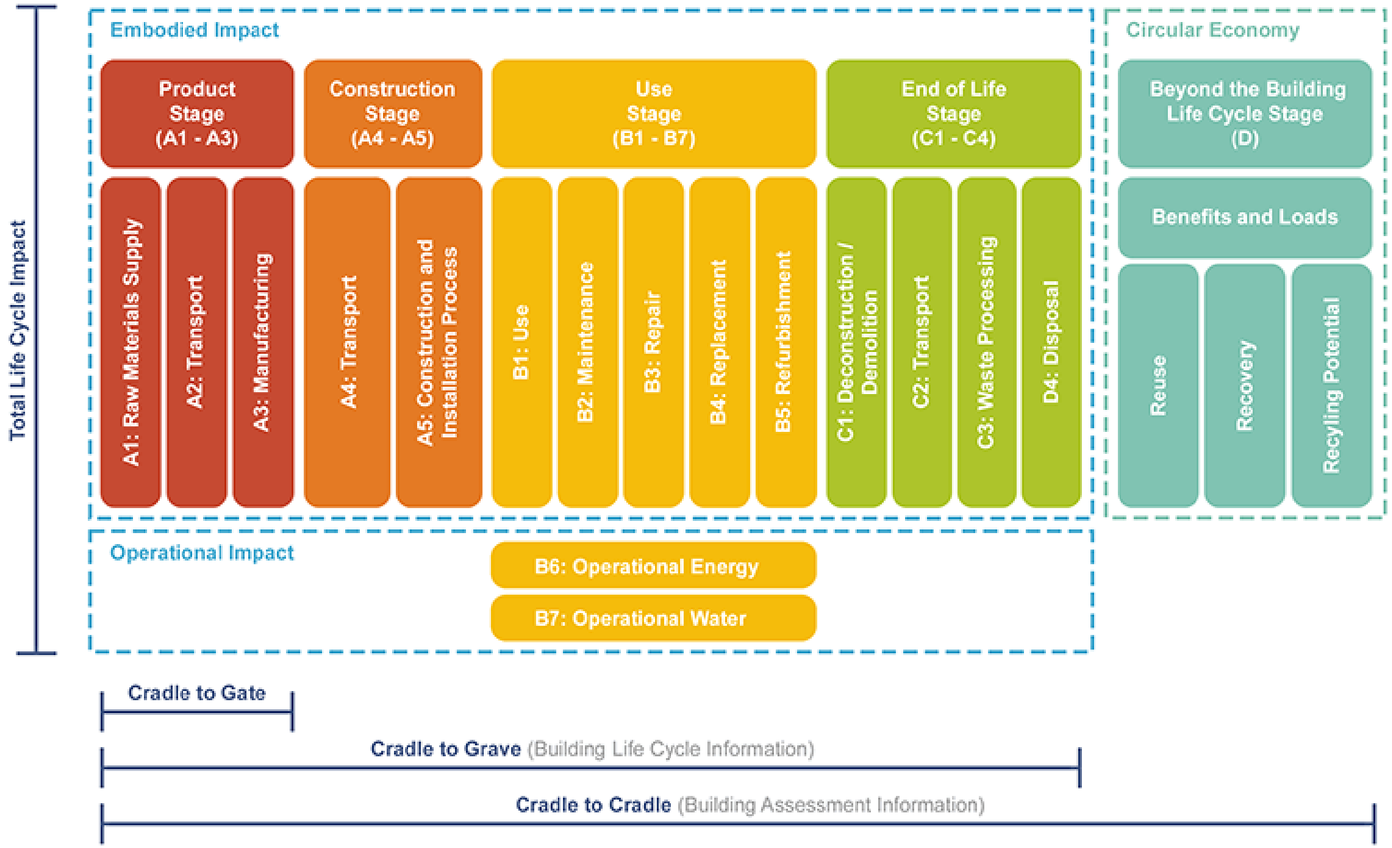
REPORTING

5 PROJECTS

GRAEF is committed to tracking and reporting embodied carbon on a minimum of five (5) projects per year. Data from these projects is submitted to SE 2050. It is also compiled in an internal database to enable comparisons and reduction tracking. The Embodied Carbon Champion is engaged with office leaders from each office location with structural engineering services to identify potential clients and/or projects to use as case studies. We will continue to update our goals and strategy based on the data we collect.

REPORTING

LIFE CYCLE STAGES (ISO 14040, EN 15978) *Image originally published in 2021 by BNP Media through the Building Enclosure Blog*



GRAEF utilizes software and tools to measure, track, and report embodied carbon from the projects we report on, employing data from product-specific, plant-specific, and/or region-specific Environmental Product Declarations (EPDs) when available.

The tools and methodology for calculating embodied carbon and the scope of the LCA is dependent on the project stage, project size, and project goals, but include Cradle-to-Gate Life Cycle Stages [A1-A3] at a minimum. For most projects, Life Cycle Stages envelopes Cradle-to-Grave Life Cycle Stages [A1-C4] and does not include Module D or Biogenic Carbon. For earlier design stages, material quantities are calculated “by-hand” in Microsoft Excel. For projects further along in development, material quantities are be tabulated in REVIT via itemized schedules or exported from REVIT to an LCA software/tool.

Please see Table 1 on the following page for a summary of our carbon analysis and reporting plan, including current and planned LCA software and tools.

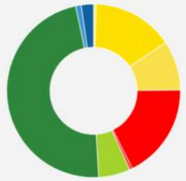
Software / Tool	Project Stages	Life Cycle Stages LCA Scope	Data Inputs	Data Output
ECOM - Embodied Carbon Estimator (se2050.org/ecom-tool) 	Early design through Construction	A1-A3 (Cradle-to-Gate)	Building Structural Material Quantities (estimates based on preliminary structural member sizes)	GWP (Global Warming Potential) in pounds or kilograms of CO_2 equivalent
Embodied Carbon in Construction Calculator (EC3) Tool + TallyCAT	Design Development through Construction	A1-A3 typically, including A4 and A5 if data is available	Estimated Material Quantities (from 3D modeled structural elements in Revit model, if available), Selection of EPDs	GWP as well as other Environmental Impact Indicators via online platform, including a variety of auto-generated graphics
Tally (Revit Add-in)	Design Development through Construction	A1-C4, excluding A5 in some cases (Cradle-to-Grave)	3D Modeled Structural Elements in Revit Model, Assigned Structural Material Properties (either in Revit or Tally)	GWP as well as other Environmental Impact Indicators via an Excel spreadsheet and PDF file including variety of auto-generated graphics

TABLE 1: GRAEF'S EMBODIED CARBON CALCULATION SOFTWARE AND TOOLS

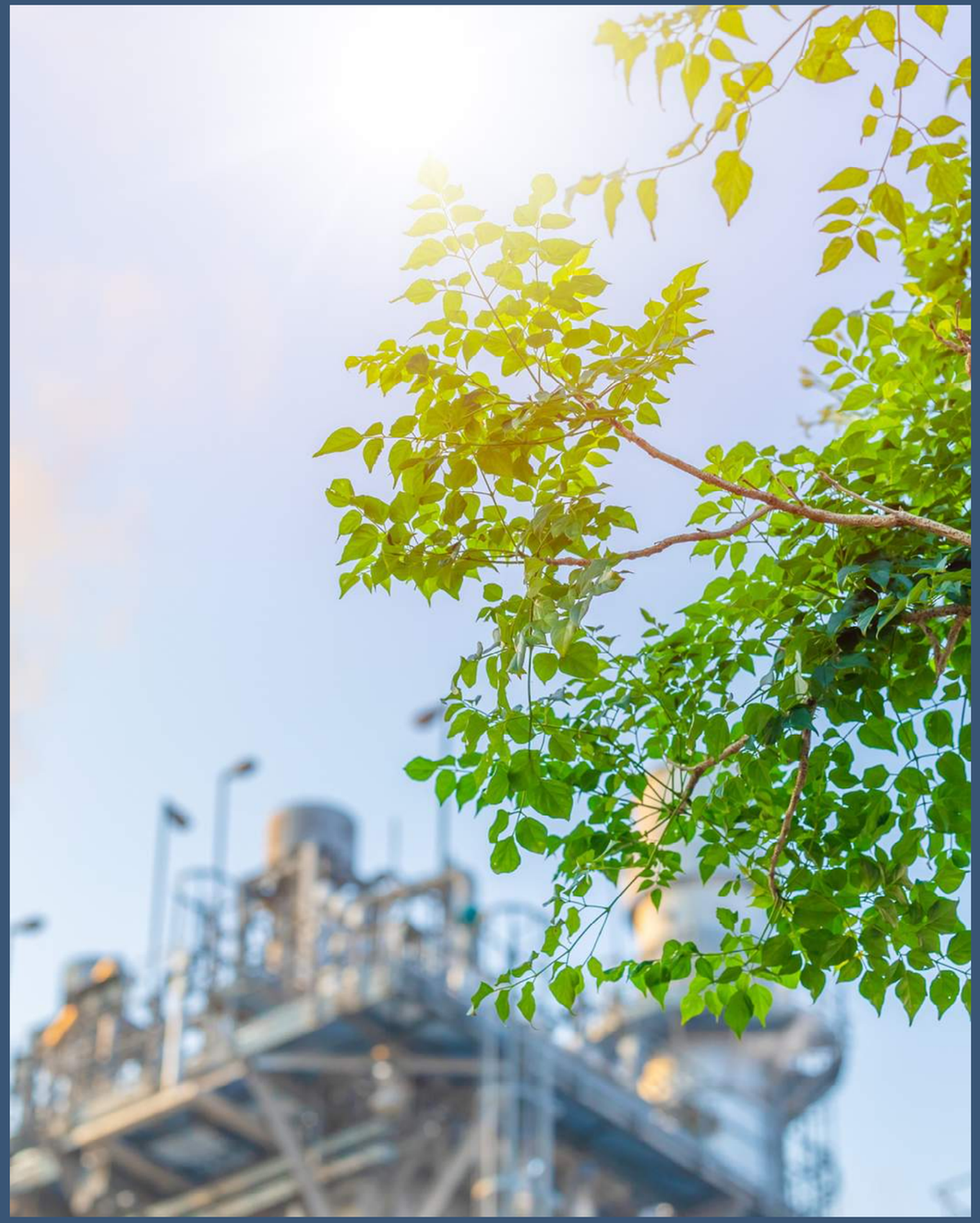
REDUCTION

Structural steel contains a high percentage of recycled content, while wood is a renewable resource. With these materials already offering sustainability benefits, we have focused on making our concrete structures more environmentally friendly. Our performance-based concrete specification allows ready-mix plants to design their own mixes, and we permit a 56-day minimum compressive strength requirement to accommodate slower-curing, more sustainable mixes. GRAEF establishes the minimum compressive strength, permeability resistance, and durability standards required for harsh, freezing conditions (Exposure F3 per ACI).

GRAEF advocates for sustainable concrete mixes and encourages owners to utilize options that reduce embodied carbon. We have updated our 03 30 00 Structural Concrete specification to align with the maximum recommended values for Supplementary Cementitious Materials (SCMs) per the Portland Cement Association (PCA) and National Ready Mixed Concrete Association (NRMCA):

- Fly ash or other pozzolans: Up to 25% by mass
- Slag cement: Up to 50% by mass
- Silica fume: Up to 10% by mass
- Total fly ash, natural pozzolans, and silica fume: Up to 35% by mass
- Total fly ash, natural pozzolans, slag cement, and silica fume: Up to 50% by mass

By incorporating Portland-limestone cement (Type 1L), we have achieved up to **20% reduction in Global Warming Potential (GWP)** compared to the Great Lakes regional average on multiple projects. Moving forward, we hope to collaborate with our **SE2050 partners** to further increase these reductions.



LESSONS LEARNED

Concrete mix design is both an art and a science, especially in demanding applications like parking structures. Extending a structure's lifespan delays structural replacement and reduces maintenance, contributing to sustainability. As admixture technology continues to evolve, we require concrete that meets multiple performance criteria: structural integrity, durability, low permeability, resistance to deterioration, protection for steel reinforcement, flowability, and workability—all while improving sustainability.

SUSTAINABLE MIX CONSIDERATIONS

To ensure proper performance of a sustainable high-performance mix, we conduct test pours and mockups on every project to fine tune the admixtures for workability. Post-tensioned concrete must reach sufficient compressive strength within 24 hours to enable tendon cable tensioning and prevent shrinkage cracking. On large pours, we had to provide retarders at the start and accelerants at the end to synchronize curing to prevent differential shrinkage cracking. For one project, we even had to enclose and heat the underside of the formwork—in the middle of summer—to achieve uniform curing, a solution that surprised everyone involved. The applied heat during winter needed to be maintained at a higher temperature for a longer duration to compensate for the reduced heat of hydration.

KNOWLEDGE SHARING

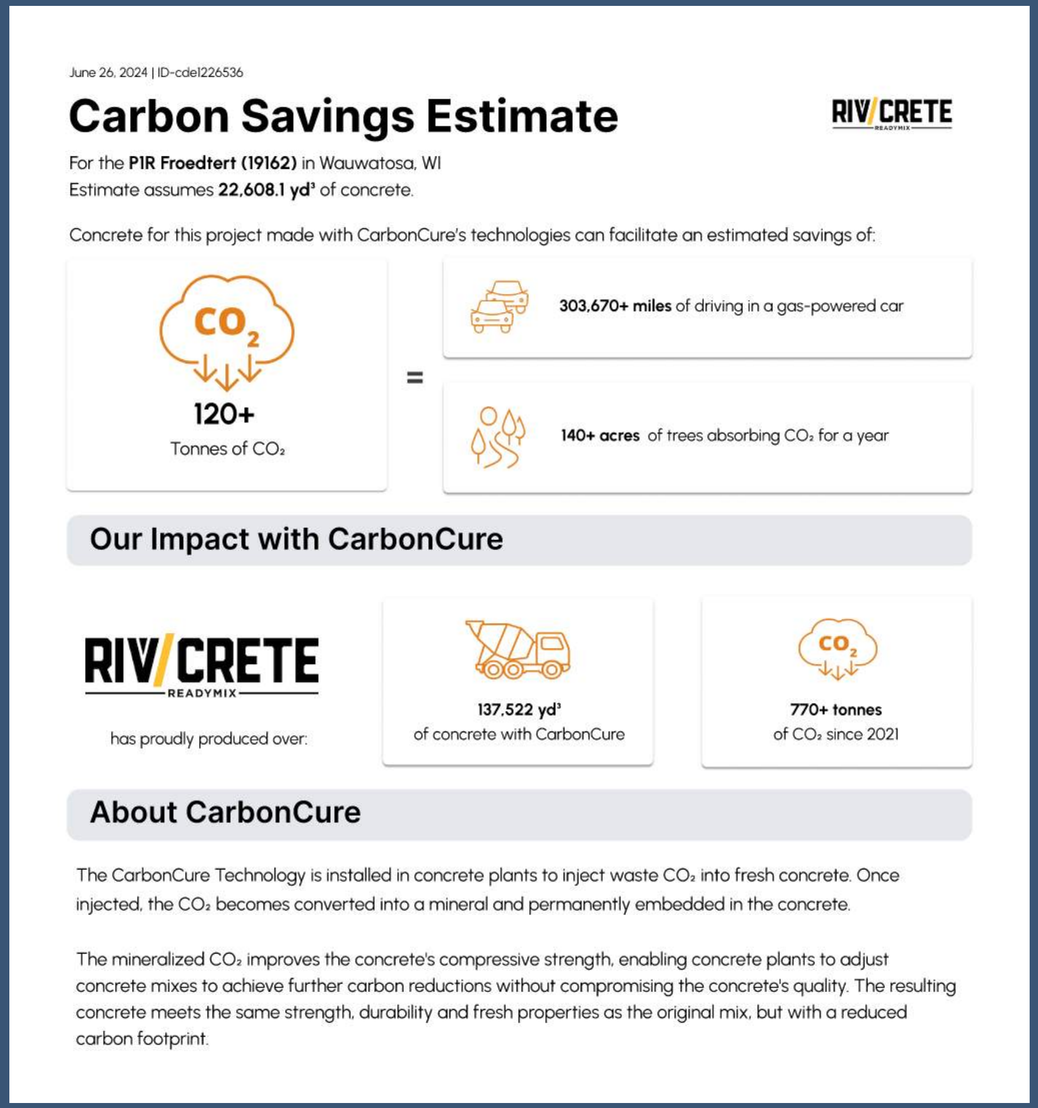
GRAEF strives to provide clients a wealth of information to inform project decisions. Experience with reduction strategies, as well as insights from LCAs, form a valuable knowledge base for sustainable design. Continued internal data collection will help to drive metrics involving embodied carbon.

COMMUNICATING REDUCTION SUCCESS

For the Froedtert Parking 1 Replacement project, sustainability was identified by the hospital as a key design pillar for the concrete structure. We provided initial Life Cycle Assessment (LCA) projections at project kickoff and continued to update them as the parking deck was poured, reflecting increased carbon reductions over time.

Monthly reports generated by CarbonCure and the ready-mix contractor were shared with Froedtert on a bi-monthly basis. Froedtert's marketing team used this data to create and distribute sustainability progress updates internally and also installed display boards in a lobby adjacent to the construction site to highlight the project's sustainability efforts.

GRAEF plans to implement tracking reports to communicate carbon reduction progress. This information is especially useful on projects with many large concrete pours, as ongoing tracking can reveal trends in carbon data throughout the construction timeline.



June 26, 2024 | ID-cdel226536

Carbon Savings Estimate

RIV/CRETE READYMIX

For the **P1R Froedtert (19162)** in Wauwatosa, WI
Estimate assumes **22,608.1 yd³** of concrete.

Concrete for this project made with CarbonCure's technologies can facilitate an estimated savings of:

CO_2

120+
Tonnes of CO_2

=

303,670+ miles of driving in a gas-powered car

140+ acres of trees absorbing CO_2 for a year

Our Impact with CarbonCure

RIV/CRETE READYMIX has proudly produced over:

137,522 yd³
of concrete with CarbonCure

770+ tonnes
of CO_2 since 2021

About CarbonCure

The CarbonCure Technology is installed in concrete plants to inject waste CO_2 into fresh concrete. Once injected, the CO_2 becomes converted into a mineral and permanently embedded in the concrete.

The mineralized CO_2 improves the concrete's compressive strength, enabling concrete plants to adjust concrete mixes to achieve further carbon reductions without compromising the concrete's quality. The resulting concrete meets the same strength, durability and fresh properties as the original mix, but with a reduced carbon footprint.

ADVOCACY

GRAEF is working to incentivize industry-wide change through education and advocacy. Through extensive participation in industry organizations, GRAEF will share our experiences performing Life Cycle Analyses and embodied carbon reduction strategies used on projects. In order to advocate the use of these tools, open-sourced sharing of lessons-learned will be necessary in driving industry change.

In developing informative data sets to educate clients, GRAEF plans to share that knowledge externally throughout the industry by further educating on embodied carbon through specific project examples, material carbon comparisons, and case studies. As we grow our embodied carbon knowledge and expertise within the firm, we will inform clients on the environmental impacts of design decisions early in a project. By communicating embodied carbon reduction opportunities through informative marketing materials and early design conversations around carbon reduction targets or project sustainability goals, we hope to educate clients on what is possible and how big of an impact we can make in the path toward decarbonization.

With industry demand of materials transparency on the rise, it will be imperative to collaborate with building materials manufacturers, fabricators, and producers to ensure carbon-smart product choices. GRAEF has already begun to implement a performance-based concrete specification which allows for lower embodied carbon mixes to be implemented on projects. Through steadfast engagement of contractors and material suppliers during design, we will continue to drive market trends toward a net-zero carbon future.

Website

Knowledge Sharing

Client Education + Engagement

Contractor Engagement

THANK YOU
STAY IN TOUCH

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"We are proud to do our part as GRAEF engineers to fight climate change one road, one wall, one slab, one step at a time."

GEORGE CARR PE

Structural Engineer
Embodied Carbon Champion
MILWAUKEE, WI

GRAEF | SEI ASCE STRUCTURAL ENGINEERING INSTITUTE | SE2050 COMMITTING TO NET ZERO

EMBODIED CARBON ACTION PLAN

APPENDIX

DOCUMENTATION OF SE 2050 PROGRAM REQUIREMENTS AND ELECTIVES

SE 2050 Program Task	Status	Required or Elective	Implementation Notes
Education:			
Provide a narrative of how the Embodied Carbon Champion will engage embodied carbon reduction at each office.	☑	Required	(Reference page 8 of this document)
Present at least (1) webinar focused on embodied carbon and make a recording available to employees.	☑	Required	"The Top 10 Ways to Reduce Concrete's Carbon Footprint" NRMCA presentation on Sept 24, 2025.
Initiate an embodied carbon interest group within your firm and outline their goals. This group may more broadly address sustainability, but they must include embodied carbon.	☑	Elective	GRAEF's Structural Sustainability Committee (Reference page 6 of the ECAP for more details).
Train your firm's structural engineers on the core concepts and skills required to measure, reduce, and report embodied carbon. (Ref. SE 2050 Resources)	In Progress	Elective	Several Structural Engineers received Tally training in 2025. Plans for wider rollout in development.
Create an Embodied Carbon digital resource wiki and/or forum on your firm's internal website for staff to create, share, and discuss Embodied Carbon educational resources.	In Progress	Elective	Structural Sustainability resource page on intranet is in development.
Reporting:			
Submit a minimum of (2) projects per U.S. office with structural engineering services to the SE 2050 Database. You are not required to submit more than (5) total projects across your firm.	☑	Required	LCA data for (5) projects submitted March 2026.
Compare the embodied carbon emissions from multiple projects across your firm. Analyze and document what data or pieces of information are most important and communicate the findings to your firm.	In Progress	Elective	Life Cycle Assessment database and interactive dashboard is in development, to assist with analyzing data and communicating our reduction progress.
Include all structural material quantities in your submissions to the SE 2050 database.	☑	Elective	SMQ data for (5) projects submitted March 2026.

TABLE 2: GRAEF'S DOCUMENTATION OF SE 2050 REQUIREMENTS AND ELECTIVES (continued on following page)

DOCUMENTATION OF SE 2050 PROGRAM REQUIREMENTS AND ELECTIVES (CONT'D)

SE 2050 Program Task	Status	Required or Elective	Implementation Notes
Reduction:			
Develop and implement a workflow that makes it easier to make early design decisions based on embodied carbon.	In Progress	Required	The Structural Sustainability Committee is collaborating with Structural Technical Committees to develop workflows for assessing reduction potential on different project types.
Collaborate with your concrete supplier to reduce embodied carbon in a mix design below an acceptable baseline (e.g. NRMCA regional baseline values). Discuss what you found and what it means in your market.	☑	Elective	GRAEF collaborated with Lycon Concrete to optimize mix designs for select projects.
Update specifications to incorporate embodied carbon performance. Include embodied carbon in your submittal review requirements.	In Progress	Elective	Specifications have been updated on select projects to include embodied carbon considerations. Efforts to incorporate into standard specifications are in progress.
Advocacy:			
Describe the value of SE 2050 to clients. How can your design teams collaborate to reduce embodied carbon? Please attach any associated marketing materials.	In Progress	Required	Discussions with WI DOA Division of Facilities Development about structural embodied carbon considerations in state projects.
Engage with structural material suppliers in your region to communicate the importance of Environmental Product Declarations (EPDs) and low-carbon material options.	☑	Elective	Advocated for sustainable mix designs with SCMs beyond standard mixes provided by ready-mix suppliers.

TABLE 2: GRAEF'S DOCUMENTATION OF SE 2050 REQUIREMENTS AND ELECTIVES (continued from previous page)