HGA

# SE 2050 Embodied Carbon Action Plan

2021

# The Future

Climate change is the impending reality of the planet. Architecture 2030 reports that the construction industry contributes almost 40% of total global carbon dioxide emissions that cause intensely severe consequences emanating from increasing global temperatures. There is no choice but for firms like HGA to take action on the climate crisis.

HGA will continue reducing operational carbon while additionally focusing on eliminating embodied carbon found in structural materials. Implementing design strategies like elongating building life-span, designing for circularity, and material quantity optimization will be crucial for HGA in the pursuit of decreasing global warming potential impacts.

HGA's structural engineers will adapt our current practices according to the education and tools necessary for meeting the SE 2050 Commitment. HGA believes that the requirements of SE 2050 and the positive impact they generate for the planet are achievable through the strategies outlined in this document. Assessing successes and opportunities for future betterment has always been part of HGA's design process. In hopes to help catalyze the construction industry in tailoring embodied carbon reduction strategies into their practice, HGA will share lessons learned from project experience.

HGA understands that tackling embodied carbon not only falls on architectural and engineering disciplines. Other industries related to construction have a responsibility in the success of limiting global warming potential impacts. HGA believes committing to the SE 2050 Challenge aids in encouraging these industries to follow suit by generating demand for materials and construction practices that help us all achieve this goal, creating a better future for tomorrow.

**Education**

Accelerate knowledge on embodied carbon and reduction strategies firm-wide so all staff understands why it is a priority for HGA and where they may be able to help tackle emissions reductions.

**Reporting**

Tracking relevant project and LCA data will be imperative to manage how HGA refines its embodied carbon reduction strategy for future benchmarks and project goals.

**Embodied Carbon Reduction Strategies**

Learning new workflows and implementing design practices that decrease embodied carbon will help HGA discover opportunities on incoming and developing projects for pursuing embodied carbon reductions.

**Advocacy**

Finding outlets to encourage all construction-related industries to pursue lower embodied carbon methodologies and product specifications by increasing their market demand and informing clients/owners of HGA's pursuit of net-zero embodied carbon.

SEI ASCE STRUCTURAL ENGINEERING INSTITUTE

SE2050 COMMITTING TO ZERO

# Education

On February 11th, 2021, HGA issued a public announcement that the firm had joined the SE 2050 Commitment to Carbon Neutral Structural Systems. HGA broadcast the announcement through multiple channels, including our internal intranet page, sustainability council meetings, and structural department meetings.

Background knowledge of embodied carbon will be critical for all designers at HGA. Some will need more specific training. Our education approach will be tailored to provide the relevant knowledge to those who want and need it. As we work to embed embodied carbon expertise in our work, education efforts will leverage existing channels within HGA. These include our cross-office structural knowledge sharing meetings and larger firmwide meetings and events.

Our structural-specific meetings will focus on helping the structural engineers understand their roles and responsibilities related to embodied carbon as well as how to start the conversations on their projects. Firmwide meetings will help to elevate the base level of embodied carbon knowledge throughout the firm.

To date, HGA has already held an introductory presentation for the entire firm with the intent to define embodied carbon and introduce SE 2050. This will be followed soon by a presentation outlining the recommended process developed by our LCA team, along with a guide for the basics of embodied carbon.

Ethan Fogle of our Alexandria, VA office is our Embodied Carbon Reduction Champion. Ethan is a Structural Designer working on his professional licensure. He graduated in 2016 from The Pennsylvania State University with a Bachelor's and Masters of Architectural Engineering. Ethan represents structural engineering on HGA's Sustainability Steering Committee.

**Share the SE 2050 library of resources with technical staff:**

SE 2050 Library has been presented to the structural engineering department and included in shared team files. It has also been posted on HGA's internal website.

**Share embodied carbon reduction strategies with your firm as outlined in Top 10 Carbon Reducing Actions for Structural Engineers document process produced by SE 2050:**

HGA has shared these ECRS in multiple firm-wide seminars and posted about them on HGA's internal website for reference.

**Present the document "How to calculate embodied carbon" to all technical staff:**

Shared in a firm-wide presentation and uploaded on HGA's internal website for utilization.

**Initiate an embodied carbon interest group within your firm and provide a narrative of their goals:**

HGA's LCA Team is committed to embodied carbon reduction and has taken leadership over the education efforts on LCA workflow development and implementation.

# Reporting

HGA will use One-Click LCA for measuring and tracking building phase designs. HGA will also use its Carbon Designer feature and Revit-integration tool, extracting material quantities for each stage. For early design phases (Pre-design, SD), project teams will have access to itemized LCAs from One-Click LCA on standardized structural details (e.g. 4” vs 5” slab-on-grade) to show differences in embodied carbon. HGA will engage structural engineers early in the design process. Extrapolating early single-bay LCAs over the building footprint can help quickly evaluate structural system options through an embodied carbon lens alongside other typical evaluation metrics. The Carbon Designer tool in One-Click can also generate and optimize a generalized baseline building for comparison. In later design phases, teams will extract material quantities and track impact categories by using Revit-model integration from One-Click LCA. Since EPDs only consistently report life cycle stages A1-A3, these will be HGA’s primary focus, but the scope will include A1-C4.

In addition to embodied carbon educational seminars, all staff will have access to internal training on One-Click LCA’s Revit-integration abilities. Structural engineers will be required to attend a seminar walking through the LCA workflow process and have the tools to help them make informed decisions on embodied carbon. These include LCAs on Revit models, carbon designer baselines, and standardized menu details.

HGA is submitting work to SE 2050 from Bowdoin College featuring mass timber construction. HGA will also submit work on two buildings from CSU San Bernardino, also pursuing LEED certification.

**Internal Database:**

HGA is creating an internal database to track embodied carbon across all design phases.

**LCA Workflow:**

HGA has created a workflow document and seminar that teaches design teams step-by-step how to utilize One-Click LCA and where opportunities for embodied carbon reductions lie. This resource also informs the LCA capabilities in every design phase. Teams will have access to and awareness of the process for reporting LCA information that guides design decisions on projects.

**EPD Recommendations:**

HGA compiled a specification resource chart from EPDs on One-Click LCA of common structural materials HGA uses but with lower embodied carbon. This resource recommends generic, regional, and manufacturer-specific EPDs depending on the goal of the LCA. Project teams will specify these materials or comparable EPDs with a similar environmental impact factor.

Bowdoin College Mills Hall and Center for Arctic Studies

CSU San Bernardino

# ECRS

HGA's Embodied Carbon Reduction Strategy (ECRS) will develop through pursuing lower-carbon concrete specifications, specifying sustainably-sourced mass timber, optimizing structural design for further material efficiency, salvaging reusable materials, and designing for building reuse or deconstruction. A goal for the first year will be to demonstrate each of these five techniques on at least one of the five submitted projects to the SE 2050 database.

As part of tracking HGA's progress with reducing embodied carbon, HGA is in the process of conducting LCAs on past projects' embodied carbon data in each of HGA's common project sectors (healthcare, public-corporate, science and technology, and arts and culture). Analyzing these reports will inform better decisions regarding global warming potential as HGA moves forward with reducing embodied carbon and formulating standard internal baseline goals for common project categories to reach each year.

HGA will use publicly available tools such as the concrete LCA calculator shown below to assess concrete mix designs for our projects.

**Update your specifications and incorporate embodied carbon performance. Include embodied carbon in your submittal review requirements:**

HGA will use industry guidance to modify our concrete specification for less embodied carbon in our mix designs.

**Incorporate data visualization into your ECAP. How are you looking at data to make informed design decisions:**

Figures 1 & 2 display One-Click LCA's graphics which analyze embodied carbon by life-cycle stage and material type. HGA leverages data on embodied carbon hotspots for specifying materials with less global warming potential to maximize the most impactful reductions.

**Complete an embodied carbon comparison study during the project concept phase:**

Figures 3 & 4 show a comparison between steel and mass timber structure for a client.

**Provide a case study in your ECAP sharing embodied carbon lessons learned:**

Shown in Figure 5.

**Proposed Mix Designs**

Proposed – Total Volume of Concrete in the Building

| | Weight (lbs) | Acidification Potential (kgSO2eq) | Eutrophication Potential (kgNeq) | Global Warming Potential (kgCO2eq) | Ozone Depletion Potential (CFC-11eq) | Smog Formation Potential (kgO3eq) | Non-renewable Energy Demand (MJ) | |
|---|---|---|---|---|---|---|---|---|
| Impact of All Concrete | | 1 | 0 | 312 | 0.0000 | 20 | 3312 | |
| Total CY of All Concrete in Building | 1 | CY | | | | | | |

**NRMCA Baseline**

Baseline – Total Volume of Concrete in the Building

| | Weight (lbs) | Acidification Potential (kgSO2eq) | Eutrophication Potential (kgNeq) | Global Warming Potential (kgCO2eq) | Ozone Depletion Potential (CFC-11eq) | Smog Formation Potential (kgO3eq) | Non-renewable Energy Demand (MJ) | |
|---|---|---|---|---|---|---|---|---|
| Impact of All Concrete | | 1 | 0 | 389 | 0.0000 | 23 | 3801 | |
| | 1 | CY | | | | | | |

**Comparison**

Environmental Impact Comparison – Total Volume of Concrete in the Building

| | Weight (lbs) | Acidification Potential (kgSO2eq) | Eutrophication Potential (kgNeq) | Global Warming Potential (kgCO2eq) | Ozone Depletion Potential (CFC-11eq) | Smog Formation Potential (kgO3eq) | Non-renewable Energy Demand (MJ) | |
|---|---|---|---|---|---|---|---|---|
| Impact % vs Baseline | | -12.2% | -18.6% | -19.8% | 0.0% | -14.2% | -12.9% | |
| Better or Worse? | | ● | ● | ● | ● | ● | ● | |

**Proposed Mix – Footings – 4000 psi – 1601673**

| | | |
|---|---|---|
| Application | Footings | |
| Mix Design #/Name | 1601673 | |
| Strength (psi) | 4000 psi | |
| Total CY of Mix in Build | 1 | cubic yard |
| SCM Ratio (of SCM+Ce | 50.0 | % |
| % SCM (of Total Mix) | 7.8 | % |
| % Cement (of Total Mix) | 7.8 | % |

| | Mix Design Weight per 1 CY of Mix (lbs) | Acidification Potential (kg SO2eq) | Eutrophication Potential (kgNeq) | Global Warming Potential (kgCO2eq) | Ozone Depletion Potential (CFC-11eq) | Smog Formation Potential (kgO3eq) | Non-renewable Energy Demand (MJ) | kg/m3 |
|---|---|---|---|---|---|---|---|---|
| Cement | 315 | 0.33 | 0.03 | 148.34 | 0.0000 | 7.16 | 960.84 | 186.88 |
| Fly ash | | 0.00 | 0.00 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 |
| Slag | 315 | 0.03 | 0.00 | 3.91 | 0.0000 | 0.63 | 59.98 | 186.88 |
| Coarse Aggregate | 1,800 | 0.12 | 0.01 | 21.46 | 0.0000 | 2.77 | 334.62 | #### |
| Lightweight Aggregate | 0 | 0.00 | 0.00 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 |
| Fine Aggregate (Sand) | 1,300 | 0.12 | 0.01 | 39.73 | 0.0000 | 3.02 | 640.91 | 771.26 |
| Water | 284 | 0.01 | 0.00 | 2.71 | 0.0000 | 0.27 | 42.49 | 168.23 |
| Steel Reinforcement | 150 | 0.49 | 0.01 | 95.92 | 0.0000 | 5.81 | 1272.67 | 88.99 |
| Air Content | 1.50% | | | | | | | |
| Per 1 CY of MIX | 4164 | 1.10 | 0.06 | 312.08 | 0.0000 | 19.67 | #### | 2470 |
| Total Impact | 4164 | 1 | 0 | 312 | 0.0000 | 20 | 3312 | 2470 |

**Baseline Mix – Footings – 4000 psi – NRMCA – Eastern Region**

| | | |
|---|---|---|
| Application | Footings | |
| Mix Design #/Name | NRMCA - Eastern Region | |
| Strength (psi) | 4000 psi | |
| Total CY of Mix in Build | 1 | cubic yard |
| SCM Ratio (of SCM+Ce | 21.4 | % |
| % SCM (of Total Mix) | 3.3 | % |
| % Cement (of Total Mix) | 12.3 | % |

| | Mix Design Weight per 1 CY of Mix (lbs) | Acidification Potential (kg SO2eq) | Eutrophication Potential (kgNeq) | Global Warming Potential (kgCO2eq) | Ozone Depletion Potential (CFC-11eq) | Smog Formation Potential (kgO3eq) | Non-renewable Energy Demand (MJ) | kg/m3 |
|---|---|---|---|---|---|---|---|---|
| Cement | 475 | 0.50 | 0.04 | 223.69 | 0.0000 | 10.80 | 1448.89 | 281.81 |
| Fly ash | 47 | 0.01 | 0.00 | 4.95 | 0.0000 | 0.24 | 53.89 | 27.88 |
| Slag | 82 | 0.01 | 0.00 | 1.02 | 0.0000 | 0.16 | 15.61 | 48.65 |
| Coarse Aggregate | 1,634 | 0.11 | 0.01 | 19.48 | 0.0000 | 2.52 | 303.76 | 969.41 |
| Lightweight Aggregate | 0 | 0.00 | 0.00 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 |
| Fine Aggregate (Sand) | 1,345 | 0.13 | 0.01 | 41.11 | 0.0000 | 3.13 | 663.09 | 797.96 |
| Water | 289 | 0.01 | 0.00 | 2.76 | 0.0000 | 0.28 | 43.31 | 171.46 |
| Steel Reinforcement | 150 | 0.49 | 0.01 | 95.92 | 0.0000 | 5.81 | 1272.67 | 88.99 |
| Air Content | 6.00% | | | | | | | |
| Per 1 CY of MIX | 4022 | 1.26 | 0.07 | 388.93 | 0.0000 | 22.94 | #### | 2386 |
| Total Impact | 4022 | 1 | 0 | 389 | 0.0000 | 23 | 3801 | 2386 |

**Proposed vs Baseline – Footings – 4000 psi – Impact Comparison**

| | Mix Design Weight per 1 CY of Mix (lbs) | Acidification Potential (kgSO2eq) | Eutrophication Potential (kgNeq) | Global Warming Potential (kgCO2eq) | Ozone Depletion Potential (CFC-11eq) | Smog Formation Potential (kgO3eq) | Non-renewable Energy Demand (MJ) | kg/m3 |
|---|---|---|---|---|---|---|---|---|
| Cement | -34% | -34% | -34% | -34% | -34% | -34% | -34% | -34% |
| Fly ash | -100% | -100% | -100% | -100% | -100% | -100% | -100% | -100% |
| Slag | 284% | 284% | 284% | 284% | 284% | 284% | 284% | 284% |
| Coarse Aggregate | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% |
| Lightweight Aggregate | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Fine Aggregate (Sand) | -3% | -3% | -3% | -3% | -3% | -3% | -3% | -3% |
| Water | -2% | -2% | -2% | -2% | -2% | -2% | -2% | -2% |
| Steel Reinforcement | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Impact % Difference | | -12.2% | -18.6% | -19.8% | #### | -14.2% | -12.9% | |
| Better or Worse? | | ● | ● | ● | ● | ● | ● | |

# ECRS


Figure 1 (left)

HGA utlizes One-Click LCA for calculating and visualzing results of baseline structural systems and Revit models once created.

Figure 2 (below)

One-Click LCA highlights material selection hotspots with the most contribution to global warming potential. This helps inform HGA design teams where the biggest areas for carbon impact reductions can be made.

**Most contributing materials (Global warming)** Compare data

| No. | Resource | Cradle to gate impacts (A1-A3) | Of cradle to gate (A1-A3) | Sustainable alternatives | |
|---|---|---|---|---|---|
| 1. | Ready-mix concrete | 611 tons $CO_2e$ | 45.3 % | Show sustainable alternatives | Add to compare |
| 2. | Steel roof and floor deck | 611 tons $CO_2e$ | 45.3 % | Show sustainable alternatives | Add to compare |
| 3. | Structural steel profiles, generic | 67 tons $CO_2e$ | 5.0 % | Show sustainable alternatives | Add to compare |
| 4. | Hollow structural steel sections | 49 tons $CO_2e$ | 3.7 % | Show sustainable alternatives | Add to compare |
| 5. | Ready-mix concrete | 11 tons $CO_2e$ | 0.8 % | Show sustainable alternatives | Add to compare |

Figure 3 (below)

Mass timber and concrete structure for embodied carbon comparison from LCA data used in schematic design considerations.


Mass Timber Structure
Comprehensive Structure:18,230 kgCO2eq
Superstructure: -11,040 kgCO2eq


Steel Structure
Comprehensive Structure: 92,455 kgCO2eq
Superstructure: 63,185 kgCO2eq

Figure 4 (above)

Steel frame and concrete structure for embodied carbon comparison from LCA data used in schematic design considerations.

# Case Study

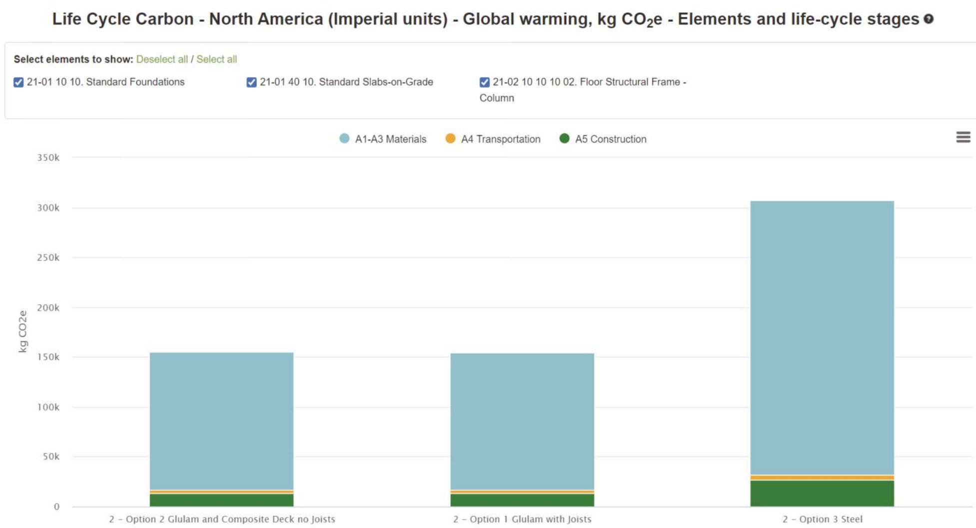


**Figure 5 (left)**

The Life Cycle Carbon Elements and life-cycle stages data comparison shows how three different structural design options compare and their respective carbon dioxide emissions. Blue represents the A1-A3 scope, where the most significant embodied carbon emissions eminate from. It is evident that Option 3 has the greatest global warming potential.

HGA utilized LCA for an education-sector project to help decide on the building structural system. The process of generating bay designs to compare via LCA helped refine the One-Click LCA workflow. HGA leveraged the software to evaluate material specifications and identify opportunities earlier in the design process to allow greater cost and carbon savings.

This project has helped HGA determine a helpful timeline of applicable actions in each design stage; expanding upon CLF's "Road Map to Reducing Building Life Cycle Impacts". HGA foresees using the Carbon Designer tool in One-Click LCA to gather an estimated baseline of carbon emissions in the Pre-Design stage. This, supplemented by the use of the Revit-integration One-Click LCA tool, allows for earlier embodied carbon evaluation on structural bay options to maximize impact for carbon reductions.

Structural bay options inform both the client and the design team where carbon and cost saving potentials are, allowing for educated choices and advocacy for lower embodied carbon options.

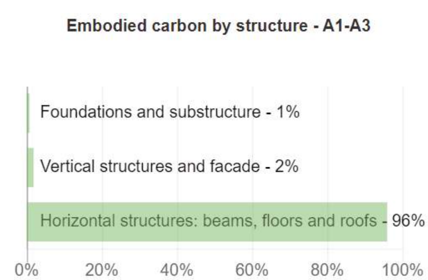


**Figure 6 (above)**

Consistently across the mass timber and steel options the majority of carbon reduction potential lies in the horizontal structural system.

# Advocacy

HGA posted its commitment to SE 2050 on the company website and LinkedIn as a form of advocacy by being publicly held accountable to this goal.

HGA is creating an internal database to analyze and discover opportunities for improvement. The resolutions will be synthesized and shared externally, contributing to the growing research on embodied carbon reduction strategies.

By specifying materials with lower global warming potential, HGA is making a statement to the manufacturing and extraction industry to also fulfill their role in helping achieve the goal of net-zero embodied carbon by 2050. With demand for lower embodied carbon products, manufacturers will have an incentive to develop or invest in methodologies that in turn generate fewer emissions contributing to global warming.

HGA has a history of creating sustainability stories that align with client goals. HGA will continue to implement strategies with their commitment to SE 2050 that prioritize realistic sustainability goals for each client. This includes presenting how lowering embodied carbon can also lower project expenses when fewer, longer-lasting materials are used. HGA is also working to incorporate LCA workflow practices into our normal design process. The knowledge gained will make us better engineeers and help our clients make informed decisions regarding their own journey to a Net-Zero Carbon future. We see our commitment to SE 2050 as an opportunity for interal growth and for advocacy to our clients and design partners as we work together to meet the challenges ahead.

**Share your commitment to SE 2050 on your company website:**

HGA announced its public commitment to SE 2050 on February 11th, 2021.

**Discuss with the owner/client the option of requiring that some of the structural materials come with facility-specific or product-specific EPDs:**

HGA will present this as an option to clients during sourcing discussions and also utilize this as an educational opportunity if necessary for the owner/client on the importance of sourcing these specifications.

**Provide a narrative of how you have encouraged industry and policy change incentivizing availability of low-carbon and carbon sequestration materials:**

HGA is developing expertise with mass-timber as its demand is increasing amongst HGA's clients. HGA is interested in sourcing sustainably harvested timber for these projects and the increase in demand provides an opportunity for this industry to grow following these practices from the beginning. HGA is also developing lower embodied carbon concrete mixes. By engaging concrete suppliers with this request, the firm is encouraging the market to trend towards sourcing lower embodied carbon concrete.