# Agency and Action in a Changing Climate:

## How SE 2050 Seeds Opportunity for Structural Engineers

Luke Lombardi, P.E.
luke.lombardi@burohappold.com


v. 22.00

**Hometown**: Olathe, KS

Structural Engineer — Thornton Tomasetti

Highrise, Seismic Design

**Co-Lead** of CLF-LA

Sustainability Consultant — BURO HAPPOLD

**Co-Chair** of SE 2050


# LEARNING OBJECTIVES

1. Understand and be able to **define embodied carbon**

1. Clearly be able to **communicate the value structural engineers bring** to clients and projects when considering embodied carbon

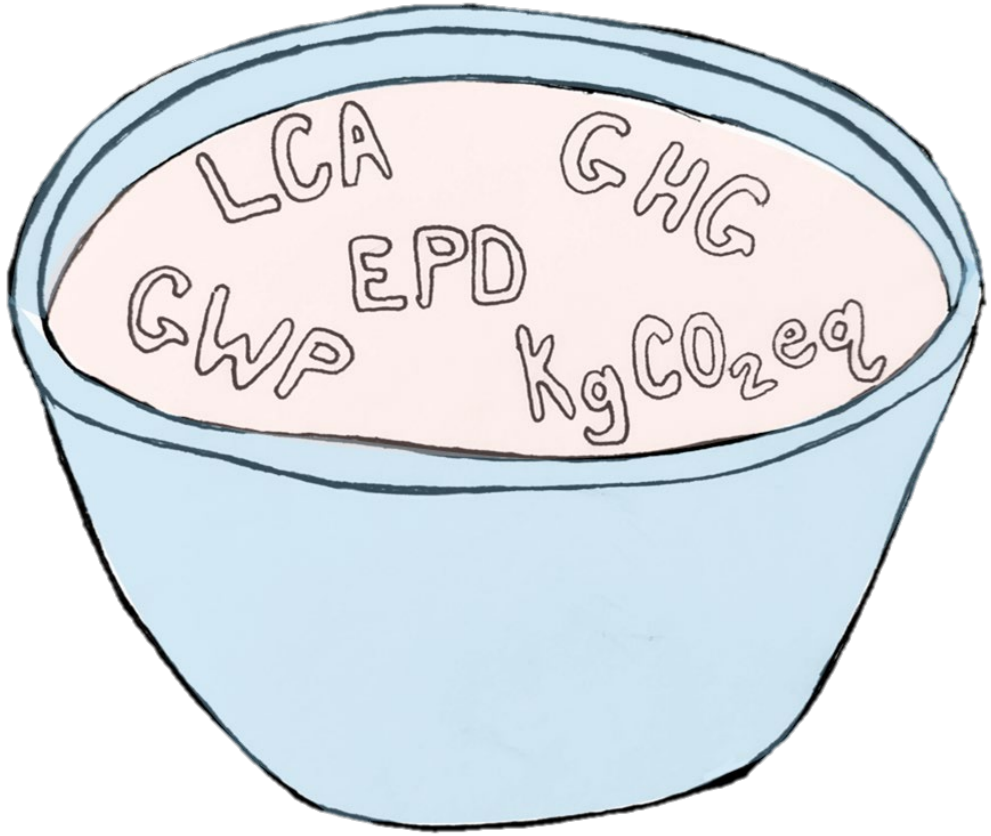
1. Learn about the **resources available** to structural engineers on se2050.org

# AGENDA

- What is **Embodied Carbon**?
- What is **SE 2050**?
  - Program Requirements
  - Database
  - Resources
- How can we address reducing **Embodied Carbon**?
  - Design Efficiency
  - Material Specification and Procurement
- What **Opportunities** exist for structural engineers?

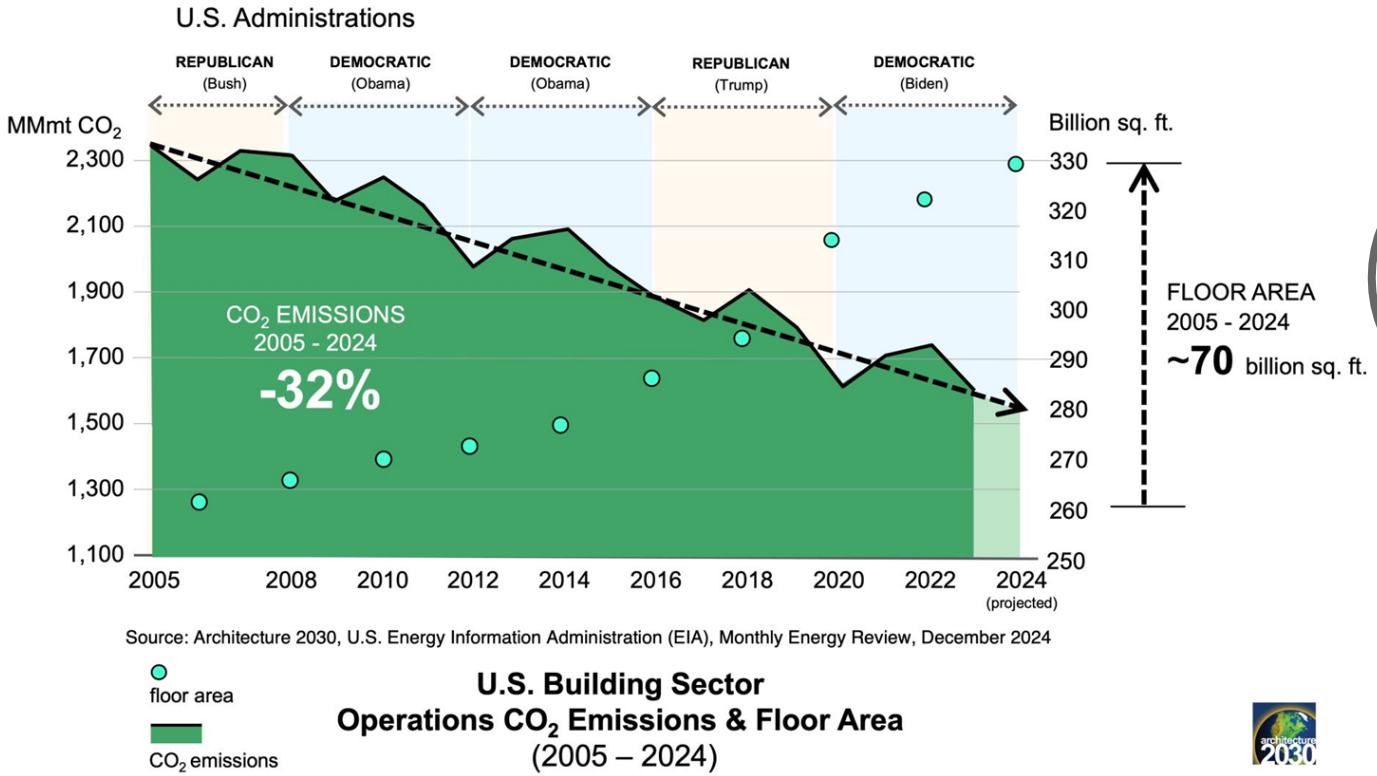
# What is Embodied Carbon?

# Terms and Definitions




| | |
|---|---|
| **GHG** | Greenhouse Gas |
| **GWP** | Global Warming Potential |
| **kgCO2eq** | unit of measure for GWP, i.e. “carbon” |
| **EPD** | Environmental Product Declaration |
| **LCA** | Life Cycle Assessment |
| **WBLCA** | Whole Building Life Cycle Assessment |

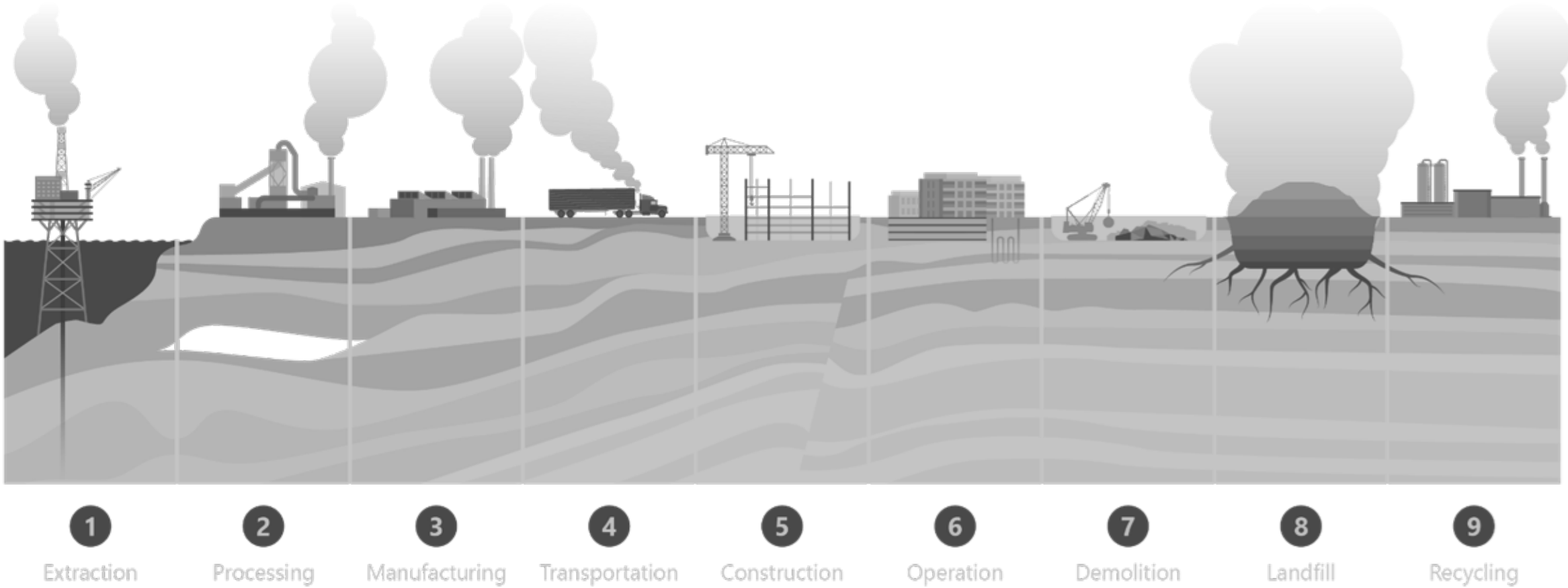
*Illustration: Laura Karnath*



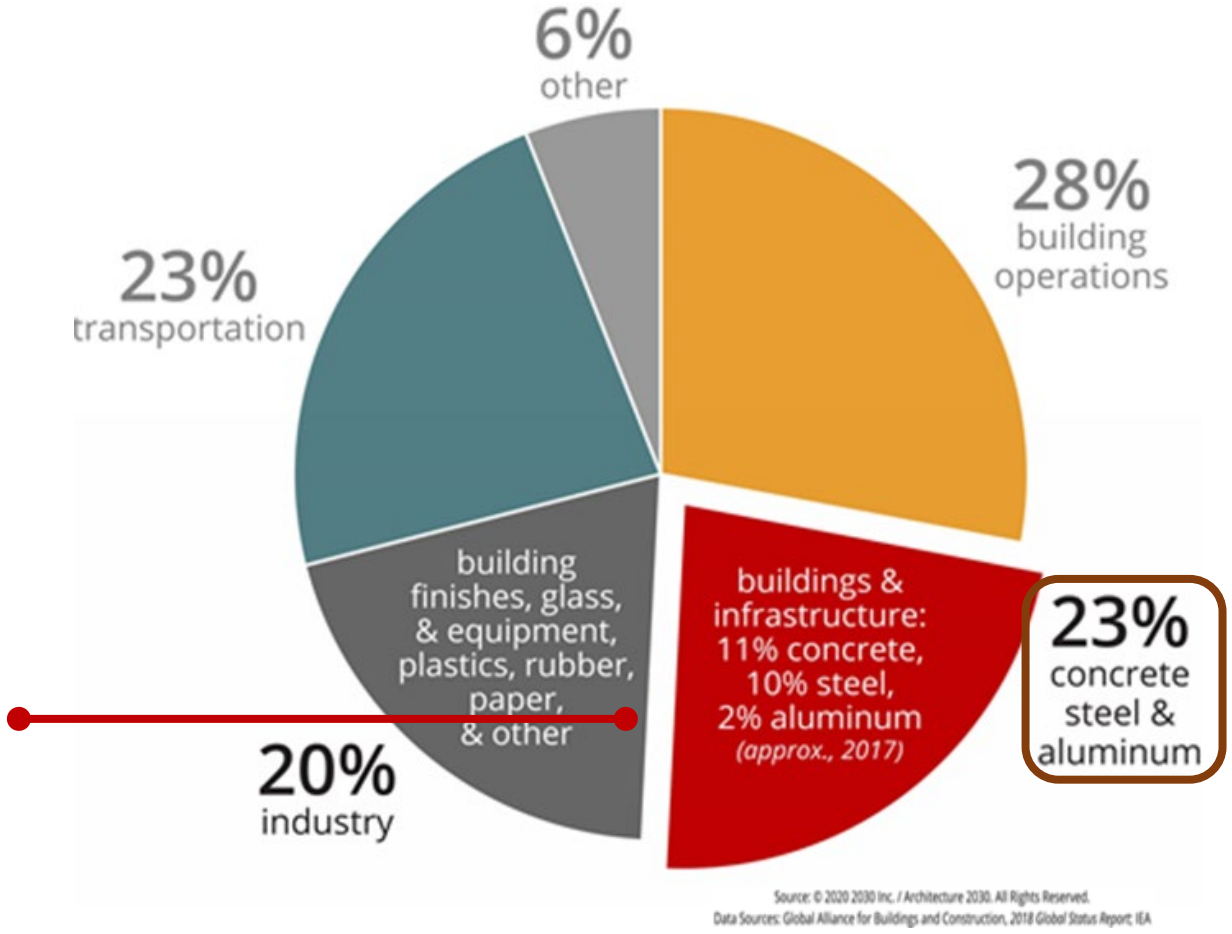

# Success!

## Reduced emissions while continuing to build

# Embodied Carbon is…



# Global CO2 Emissions by Sector



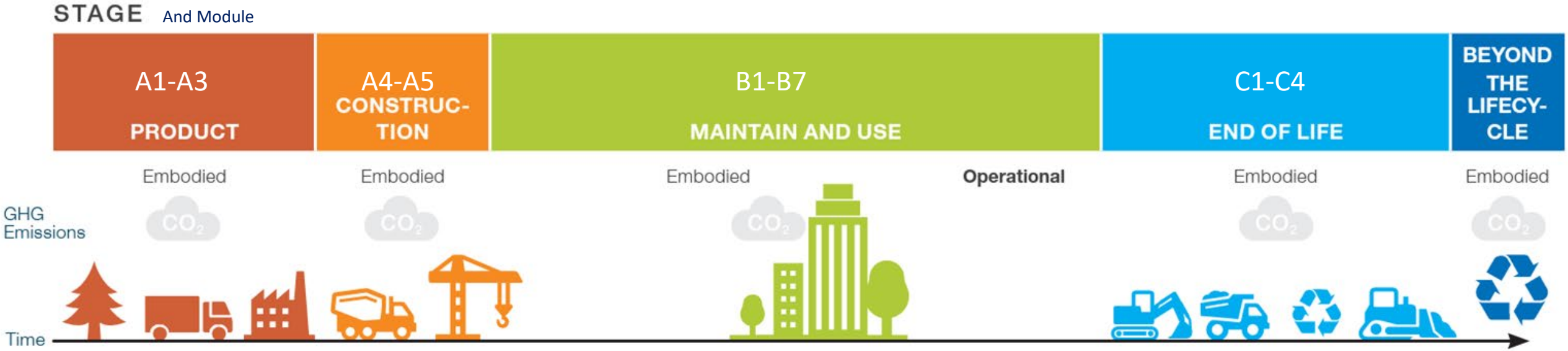
We’re building a new **New York City** **every month** for the next 30 years

Source: Architecture 2030

# Contextualizing the Impact of Structural Engineers

# Cement Manufacturing
*Mojave, CA*


# Stages of Whole Life Carbon




Credit: NBI

# Environmental Product Declarations (EPDs)

**Food Nutritional Labels**

Health Impacts

**Nutrition Facts**

Serving Size 2/3 cup (55g)
Servings Per Container About 8

**Amount Per Serving**

| | |
|---|---|
| **Calories** 230 | Calories from Fat 40 |
| | **% Daily Value*** |
| **Total Fat** 8g | **12%** |
| Saturated Fat 1g | **5%** |
| *Trans* Fat 0g | |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 160mg | **7%** |
| **Total Carbohydrate** 37g | **12%** |
| Dietary Fiber 4g | **16%** |
| Sugars 1g | |
| **Protein** 3g | |
| Vitamin A | 10% |
| Vitamin C | 8% |
| Calcium | 20% |
| Iron | 45% |

* Percent Daily Values are based on a 2,000 calorie diet. Your daily value may be higher or lower depending on your calorie needs.

| | Calories: | 2,000 | 2,500 |
|---|---|---|---|
| Total Fat | Less than | 65g | 80g |
| Sat Fat | Less than | 20g | 25g |
| Cholesterol | Less than | 300mg | 300mg |
| Sodium | Less than | 2,400mg | 2,400mg |
| Total Carbohydrate | | 300g | 375g |
| Dietary Fiber | | 25g | 30g |

**Product EPDs**

Environmental Impacts

**Environmental Impacts**

**Declared Product:**
Mix 4F05C5Q1 • Bode Plant
EF50 Gen Use 4" line w/c .50
Compressive strength: 4000 psi at 28 days

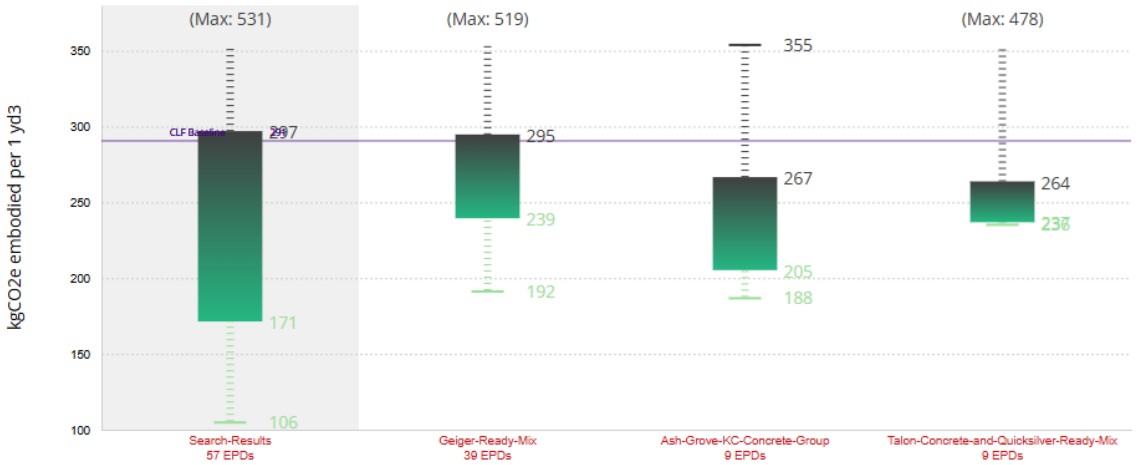
Declared Unit: 1 $m^3$ of concrete

| | |
|---|---|
| Global Warming Potential (kg $CO_2$-eq) | 272 |
| Ozone Depletion Potential (kg CFC-11-eq) | 7.4E-6 |
| Acidification Potential (kg $SO_2$-eq) | 2.06 |
| Eutrophication Potential (kg N-eq) | 0.37 |
| Photochemical Smog Creation Potential (kg $O_3$-eq) | 53.8 |
| Total Primary Energy Consumption (MJ) | 2,577 |
| Nonrenewable (MJ) | 2,504 |
| Renewable (MJ) | 70.7 |
| Total Concrete Water Consumption ($m_3$) | 3.65 |
| Batching Water ($m_3$) | 0.09 |
| Washing Water ($m_3$) | 8.8E-3 |
| Nonrenewable Material Resource Consumption (kg) | 2,494 |
| Renewable Material Resource Consumption (kg) | 1.57 |
| Hazardous Waste Production (kg) | 0.01 |
| Nonhazardous Waste Production (kg) | 2.76 |

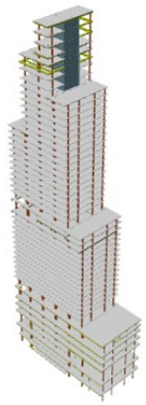
Product Components: crushed aggregate (ASTM C33), Portland cement (ASTM C150), slag cement (ASTM C989), fly ash (ASTM C618), admixture (ASTM C494), batch water (ASTM C1602)

- EPDs are LCAs of Products
- Third Party Verified
- ISO 14044 & EN 15804
- Avoids Greenwashing
- EPDs can be Industry Average or Manufacturer / Plant / Product Specific

# Concrete EPDs in the KC Metro Area



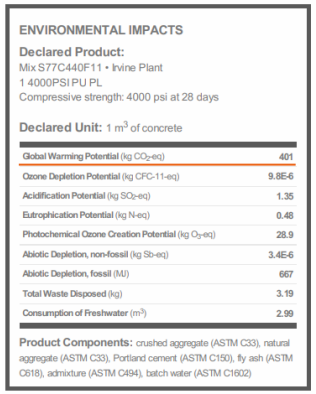
# Running the Calc



**Quantities of Building Materials**

*From BIM takeoff or hand calculation*

**X**



ENVIRONMENTAL IMPACTS

**Declared Product:**
Mix:S77C440F11 • Irvine Plant
1 4000PSI PU PL
Compressive strength: 4000 psi at 28 days

**Declared Unit:** 1 $m^3$ of concrete

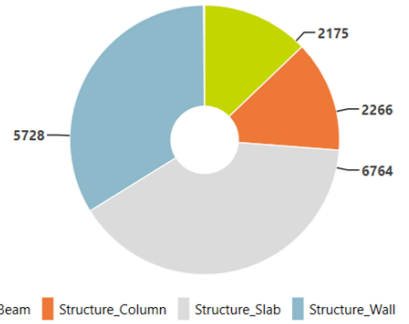
| | |
|---|---|
| **Global Warming Potential** (kg $CO_2$-eq) | 401 |
| **Ozone Depletion Potential** (kg CFC-11-eq) | 9.8E-6 |
| **Acidification Potential** (kg $SO_2$-eq) | 1.35 |
| **Eutrophication Potential** (kg N-eq) | 0.48 |
| **Photochemical Ozone Creation Potential** (kg $O_3$-eq) | 28.9 |
| **Abiotic Depletion, non-fossil** (kg Sb-eq) | 3.4E-6 |
| **Abiotic Depletion, fossil** (MJ) | 667 |
| **Total Waste Disposed** (kg) | 3.19 |
| **Consumption of Freshwater** ($m^3$) | 2.99 |

**Product Components:** crushed aggregate (ASTM C33), natural aggregate (ASTM C33), Portland cement (ASTM C150), fly ash (ASTM C618), admixture (ASTM C494), batch water (ASTM C1602)

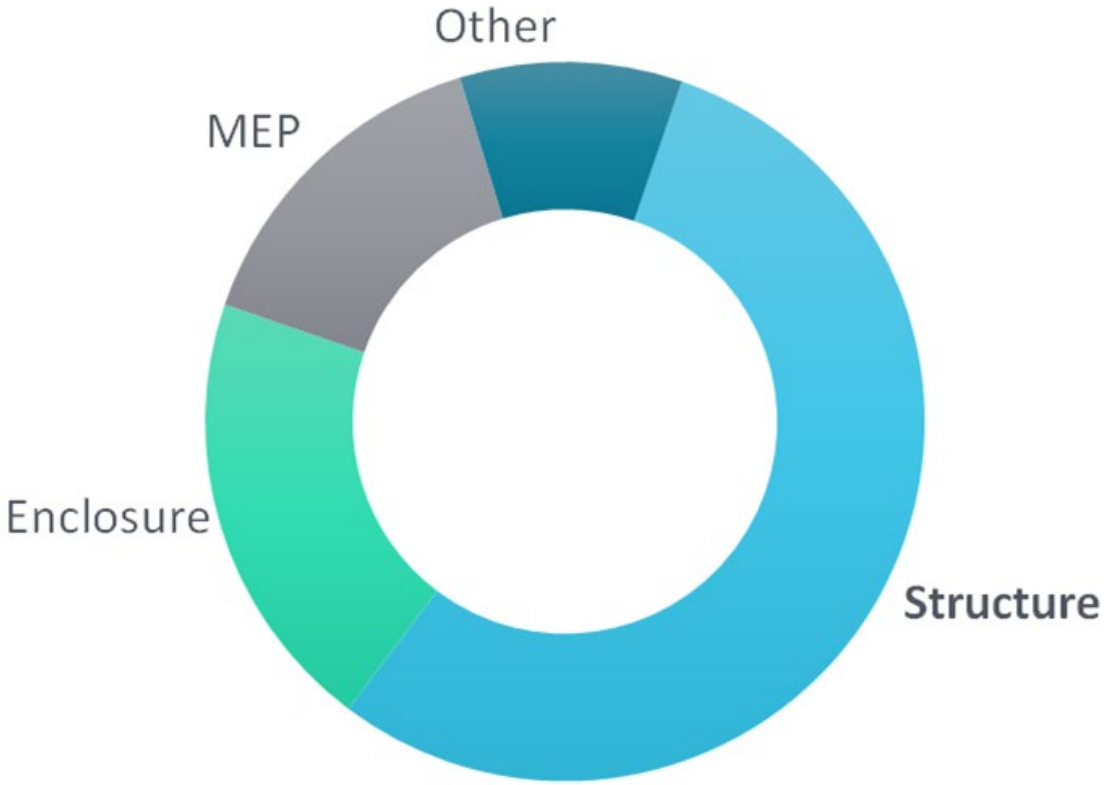
**GWP per material**
($kgCO_2e$/unit)

*from Material EPDs or other aggregated data*

**=**




**Whole Building GWP**
($kgCO_2e$)




Say **50%** of all new building embodied carbon is from **structure**
About **1.9 billion metric tons CO2 per year**

# What is SE 2050?

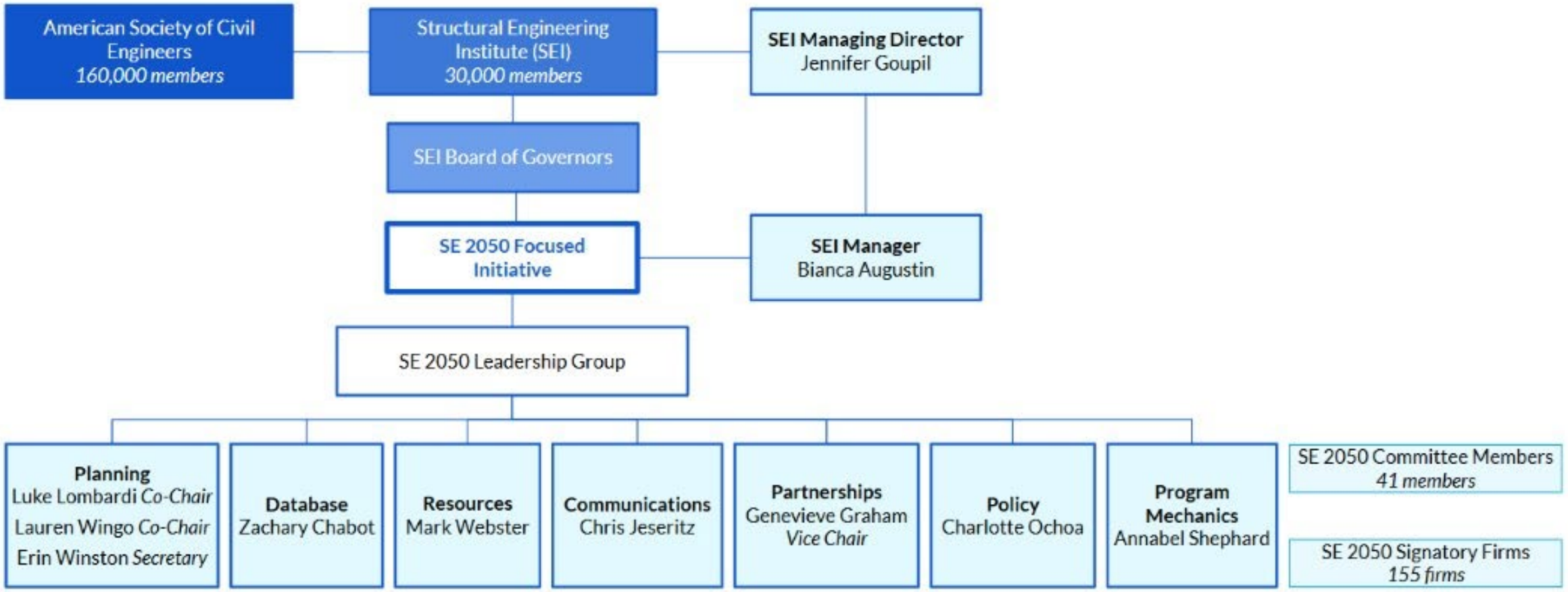

STRUCTURAL
ENGINEERING
INSTITUTE

SE2050

COMMITTING TO NET ZERO

www.SE2050.org

# Org Structure & Focus Initiative



# PROGRAM STATS – SIGNATORY FIRMS

**Firms Committed**

**+150**

**Projects Submitted to Database (Public)**

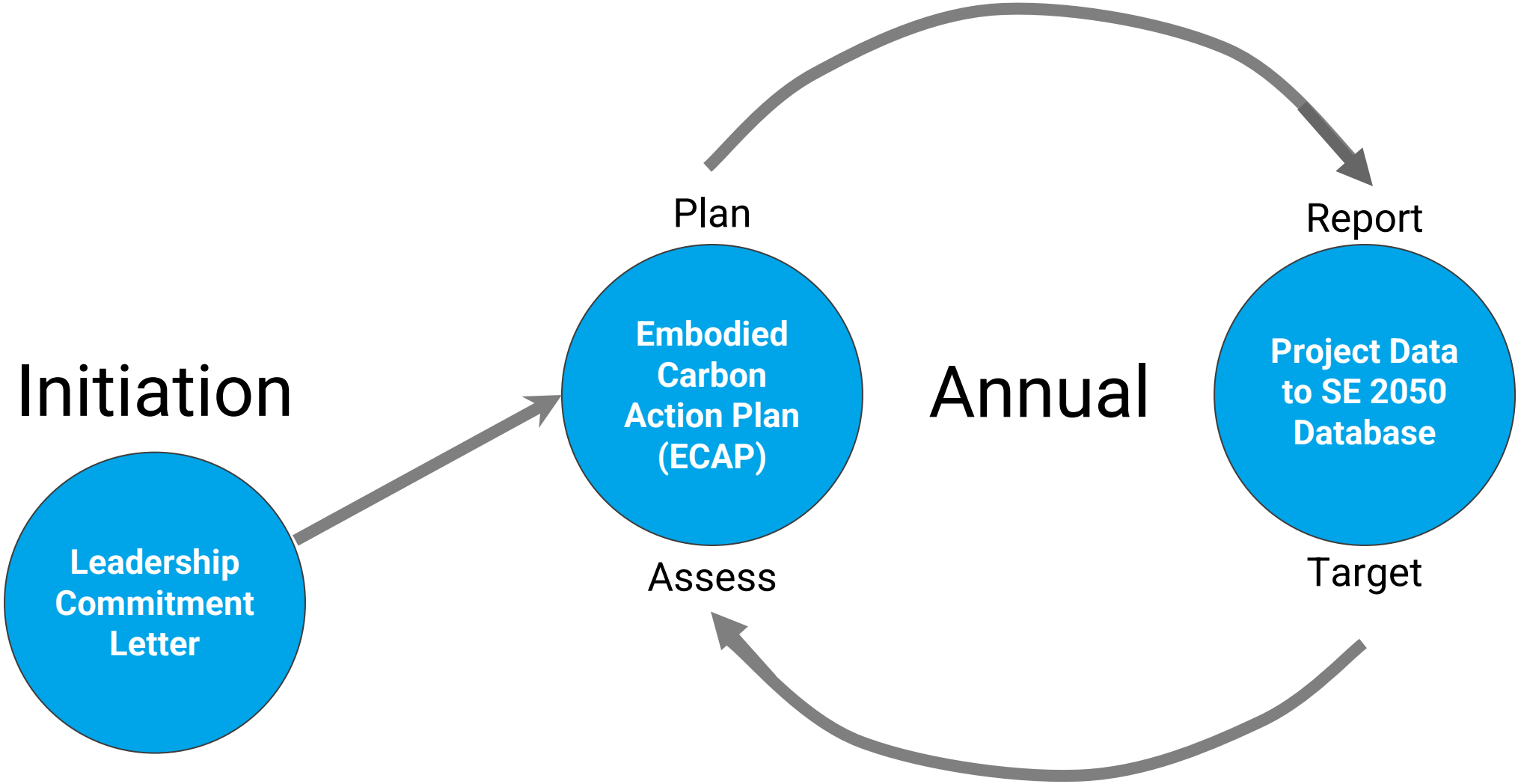
**+1,000**

**ECAPs Received**

**+250**

# PROGRAM REQUIREMENTS

# HOW IT WORKS


Initiation
Leadership Commitment Letter
Embodied Carbon Action Plan (ECAP)
Plan
Annual
Report
Project Data to SE 2050 Database
Target
Assess

# EMBODIED CARBON ACTION PLAN (ECAP)

| | KNOWLEDGE SHARING | DATA |
|---|---|---|
| INTERNAL | **Education**<br>Building Understanding | **Reporting**<br>Measuring to Manage |
| EXTERNAL | **Advocacy**<br>Building a culture of change | **Reduction**<br>Strategies Making an Impact |

# ECAP EDUCATION

- Designate Firmwide Embodied Carbon Champion
- Write up an Education Plan
- Share an Embodied Carbon 101 Presentation/Webinar
- +*lots of optional “electives”*

# Education Spotlight

Degenkolb

**ACTIONS**

**2023**

- ✓ Continued to host and increased engagement in firm-wide Embodied Carbon Interest Group (ECIG)
- ✓ Created an internal resource hub to share tools, presentations, and upcoming events
- ✓ Achieved committee involvement across our offices

**2024**

- ▸ Engage an embodied carbon expert at every office
- ▸ Expand onboarding education
- ▸ Host an external presenter to discuss embodied carbon

**BEYOND**

- ★ Provide every Degenkolber with baseline knowledge and access to resources for embodied carbon reduction on every project
- ★ Engage in industry sustainability committees in all of our geographic regions

MEMBERS OF THE DEGENKOLB SUSTAINABLE DESIGN AND WORKPLACE COMMITTEES AT OUR ANNUAL INTERNAL CONFERENCE IN SAN FRANCISCO

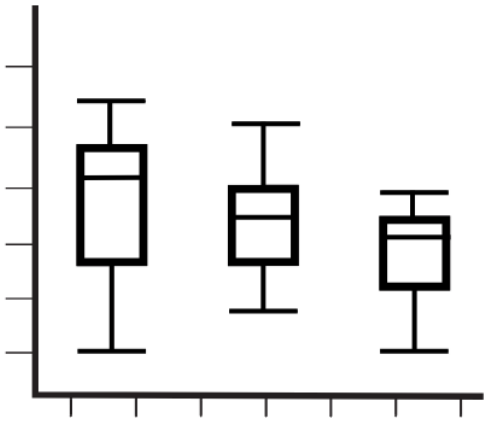
# ECAP REPORTING

- Initial Reporting Minimums to Database

  **2x** number of firm offices

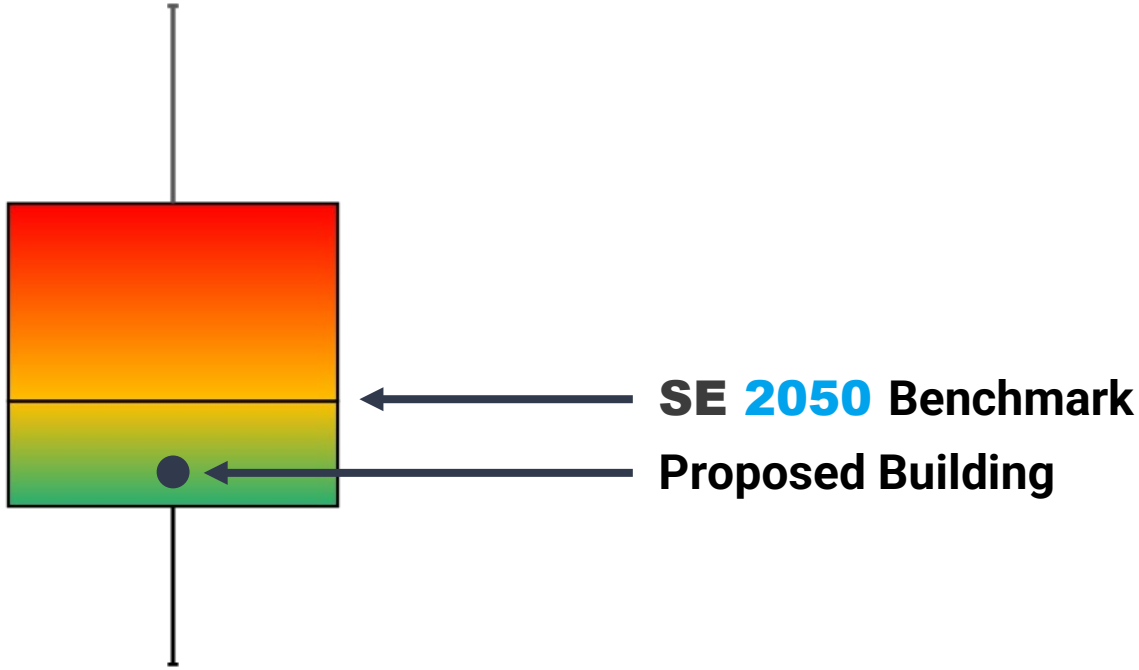
  but not more than

  **5** Projects



# SE 2050 DATABASE

# EMBODIED CARBON BENCHMARKS



# SE 2050 BETA DATABASE

**Priorities:**

Familiarize structural firms with embodied carbon reporting

Collect GWP results at minimum

Increase visibility of need for embodied carbon benchmarks

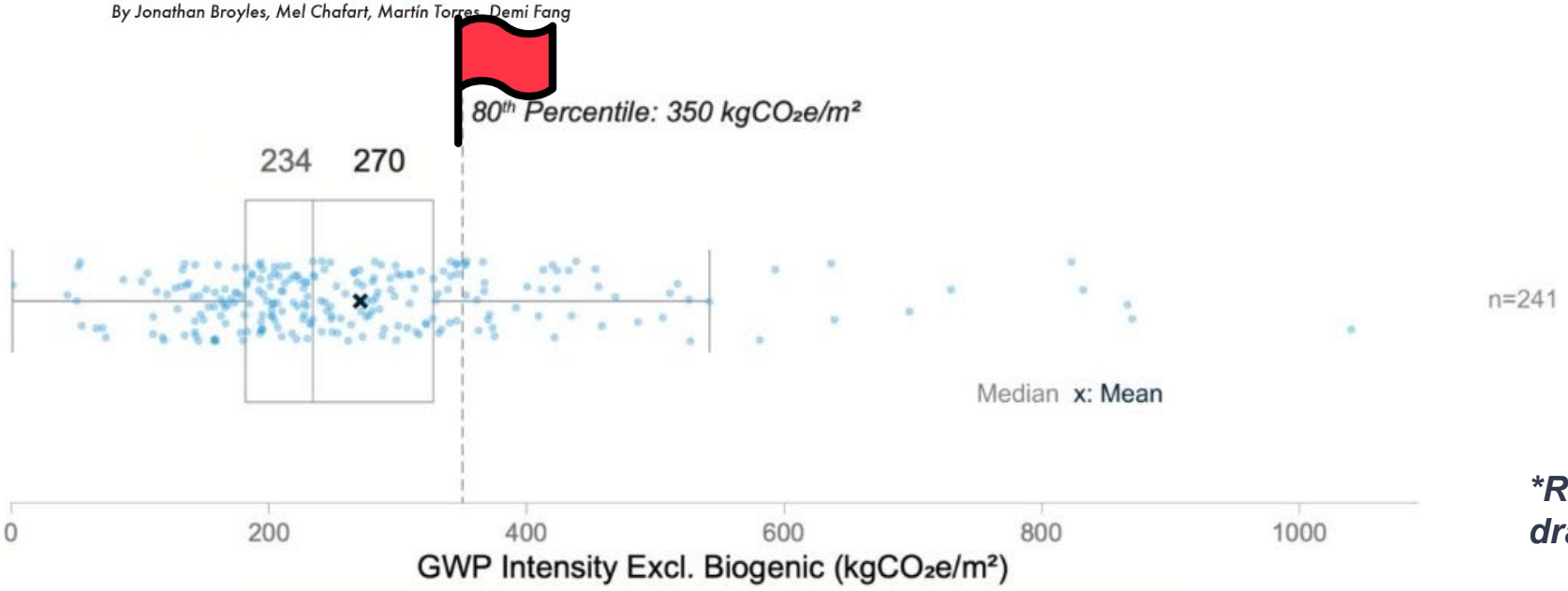
# EMBODIED CARBON BENCHMARKS

sustainable DESIGN

## Data Insights From Over 500 Building Projects for Low-Carbon Structures

*Since 2020, the SE 2050 Commitment Program has collected emissions data of over 500 building projects with corresponding structural design characteristics. Key takeaways from the inaugural analysis of the database are shared here.*

*By Jonathan Broyles, Mel Chafart, Martín Torres, Demi Fang*




***Red flag added for dramatic effect**

# Reporting Spotlight

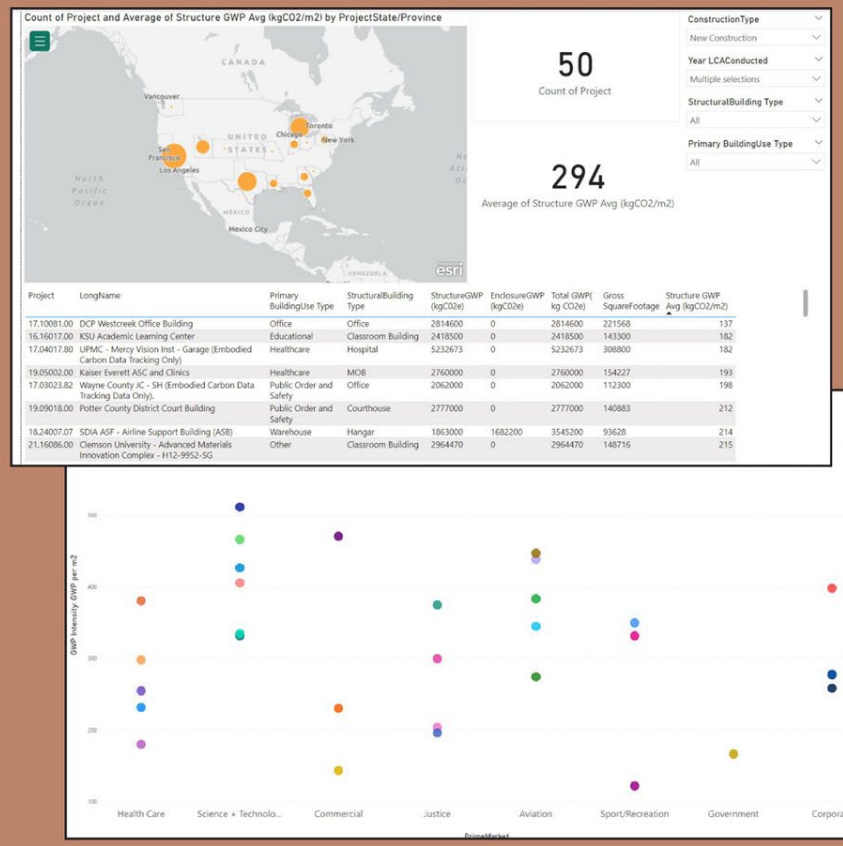
## LESSONS LEARNED

Since joining the SE 2050 challenge and enacting HOK's LCA Policy, we have 50 projects with GWP intensity data. We continue to educate project managers about the policy and importance of conducting an LCA on all eligible projects. As a next step, we are now working towards conducting multiple LCAs at different design phases on projects to implement reduction targets early.

At HOK we log project information into an internal databases which is separate from how we log projects into SE 2050's database. We are still working on a method to merge the information so that project teams do not have to input it in multiple locations. In addition, since HOK is a multidisciplinary firm and have signed up for multiple industry environmental challenges/commitments we are trying to streamline our reporting efforts; similar to CLF's ECHO project.

There currently is no US-wide industry accepted embodied carbon emissions benchmark value for buildings. Since HOK joined SE 2050 in 2020, we have focused on gathering data on projects to determine a firm-wide benchmark. We believe that a benchmark will help us make meaningful reductions and get us to net zero.

We have analyzed over 50 projects and determined that our benchma number is 295 kgCO2e/m2. Starting in 2024 we set a minimum 7% reduction to get to a 50% reduction by 2030 and eventually 100% by 2050.



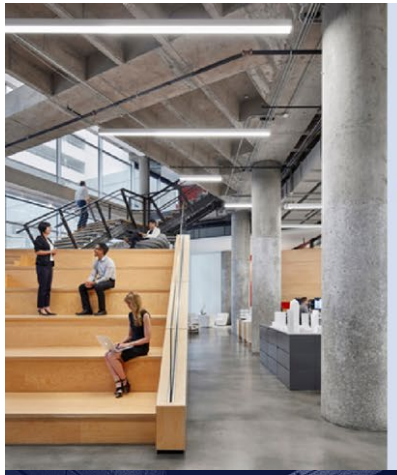

We developed a dashboard that provides basic visual aids to indicate where projects are located, what emissions are for certain market sectors, etc. We are continuing to gather more data to parse more granular conclusions and make sophisticated visual aids.

# ECAP

# REDUCTION STRATEGIES

- Set a Goal and Report on Progress
- Discuss what strategies worked and what didn't

# Reduction Spotlight



## SPECIFICATIONS

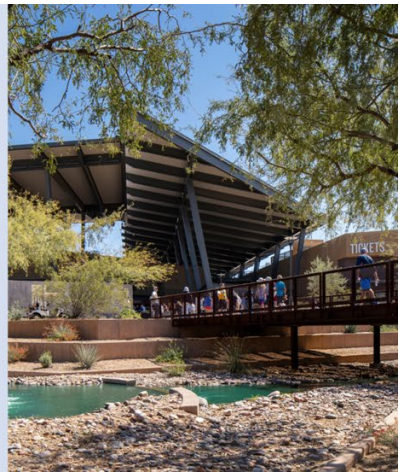
- Update the remaining material specifications to provide a low carbon specification.
- Update our standard specifications to capture the “low hanging fruit” item such as requiring EPDs.
- Work with our internal ESG department and our specification team to refine the low carbon division 1 specifications.

HKS

# REDUCTION STRATEGY

## DATA

- Aim to perform LCAs on a minimum of 50 percent of our major projects.
  - A major project is defined as a project that has a structural fee of at least $100,000, has issued construction documents, and has spent at least 100 structural man hours within the given calendar year.
  - Within these major projects, we set out to run LCAs in multiple design phases on at least half of them.
- Aim to have at least 3 projects with sustainability considerations in their schematic design narrative.

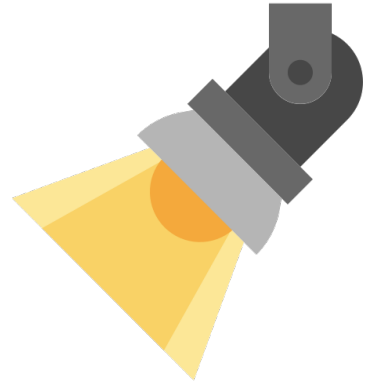


# ECAP

# ADVOCACY

- Share your commitment
- Educate clients
- Engage in groups like CLF

# Advocacy Spotlight



walter p moore

## ADVOCACY HIGHLIGHT

Greenbuild 2023 was held in Washington, DC and provided an ideal opportunity to showcase the Walter P Moore Washington DC LEED v4.1 ID+C Gold office space. During the week of Greenbuild we held multiple meetings or events that involved a mix of peers, clients, and owners. The most significant was the Carbon Leadership Forum / Building Transparency happy hour we hosted on the roof deck that had over 200 people in attendance. The DC office was also one of three stops on a formal Greenbuild tour of LEED Certified Commercial Interiors. This brought a group of approximately 25 people through the office space and allowed us to highlight the final design and its sustainability efforts.

1. We are continually harvesting and sharing our Embodied Carbon stories to advance market transformation. We share our stories through conference presentations, webinars, articles, and project case studies. We published our first collection of embodied carbon stories in **Embodied Carbon: A Clearer View of Emissions.**

2. We have sponsored the Carbon Leadership Forum (CLF) since 2014 and actively participate in our local hubs.

3. We provide educational presentations to our clients about embodied carbon, life-cycle assessment, and the importance of collaboration in reducing embodied carbon in our projects.

4. Our team actively participates in industry-wide events and embodied carbon round tables.

# RESOURCES

# SE 2050 RESOURCES

What Is Embodied Carbon?

How is Embodied Carbon Measured?

ECIDs

Top Ten Things All Structural Engineers Should Know

Signatory Case Studies (coming soon)

External Case Studies

SEI Circular Economy Case Studies

Resources for Estimating Embodied Carbon

Environmental Product Declarations

SE 2050 Embodied Carbon Estimator (ECOM)

Green Rating Systems

General Information

Specifications Guidance

Design Guidance

# SE 2050 RESOURCES

What Is Embodied Carbon?

How is Embodied Carbon Measured?

ECIDs

Top Ten Things All Structural Engineers Should Know

Signatory Case Studies (coming soon)

External Case Studies

SEI Circular Economy Case Studies

Resources for Estimating Embodied Carbon

Environmental Product Declarations

SE 2050 Embodied Carbon Estimator (ECOM)

Green Rating Systems

General Information

Specifications Guidance

Design Guidance

# ECOM


| Embodied Carbon Area | |
|---|---|
| Total Area ($ft^2$) | 1,000 |
| Total Area ($m^2$) | 92.9 |

| Embodied Carbon Totals | |
|---|---|
| Total Impact (lb $CO_2e$) | 106,572 |
| Total Impact (kg $CO_2e$) | 48,339 |

| Embodied Carbon Intensities | |
|---|---|
| Intensity (lb $CO_2e$/ $ft^2$) | 106.57 |
| Intensity (kg $CO_2e$/ $m^2$) | 520.33 |

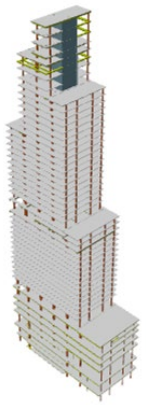
| Material | Structural Component | Quantity | Unit | Total Impact (lb $CO_2e$) | Total Impact (kg $CO_2e$) | % of Total |
|---|---|---|---|---|---|---|
| Concrete | 2,500 PSI | Input quantity here | Cubic Yards | | | 0.0% |
| | 3,000 PSI | Input quantity here | Cubic Yards | | | 0.0% |
| | 4,000 PSI | Input quantity here | Cubic Yards | | | 0.0% |
| | 5,000 PSI | 100 | Cubic Yards | 67,600 | 30,663.16 | 63.4% |
| | 6,000 PSI | Input quantity here | Cubic Yards | | | 0.0% |
| | 8,000 PSI | Input quantity here | Cubic Yards | | | 0.0% |

**Embodied Carbon**
**Order of Magnitude Estimator**

**Fast, easy, free**
**carbon calculation**

# Design and Specification Guidance
## Link to Embodied Carbon Calculation

### Design Guidance

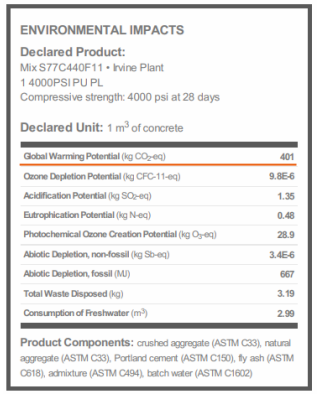


**Quantities of Building Materials**

*From BIM takeoff or hand calculation*

X

### Specification Guidance



ENVIRONMENTAL IMPACTS

**Declared Product:**
Mix S77C440F11 • Irvine Plant
1 4000PSI PU PL
Compressive strength: 4000 psi at 28 days

**Declared Unit:** 1 $m^3$ of concrete

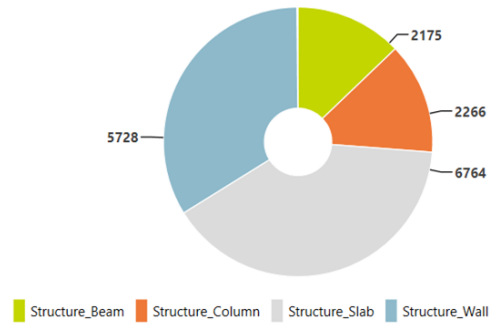
| | |
|---|---|
| Global Warming Potential (kg $CO_2$-eq) | 401 |
| Ozone Depletion Potential (kg CFC-11-eq) | 9.8E-6 |
| Acidification Potential (kg $SO_2$-eq) | 1.35 |
| Eutrophication Potential (kg N-eq) | 0.48 |
| Photochemical Ozone Creation Potential (kg $O_3$-eq) | 28.9 |
| Abiotic Depletion, non-fossil (kg Sb-eq) | 3.4E-6 |
| Abiotic Depletion, fossil (MJ) | 667 |
| Total Waste Disposed (kg) | 3.19 |
| Consumption of Freshwater ($m^3$) | 2.99 |

**Product Components:** crushed aggregate (ASTM C33), natural aggregate (ASTM C33), Portland cement (ASTM C150), fly ash (ASTM C618), admixture (ASTM C494), batch water (ASTM C1602)

**GWP per material**
($kgCO_2e$/unit)

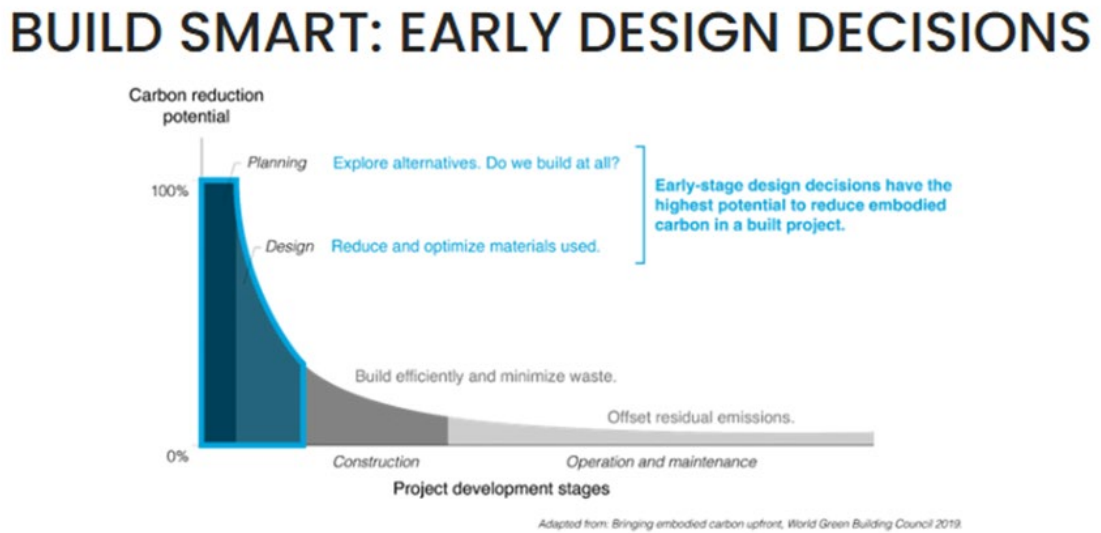
*from Material EPDs or other aggregated data*

=

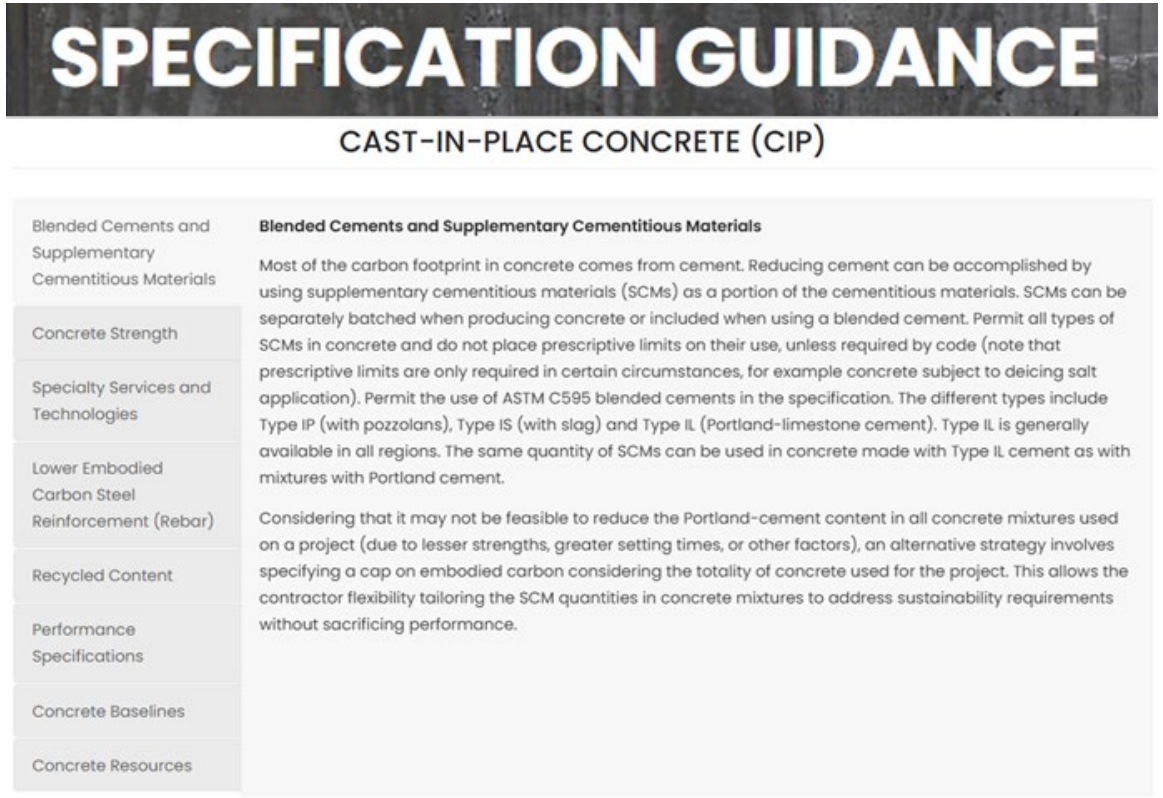



**Whole Building GWP**
($kgCO_2e$)

# **Design and Specification Guidance**
# Link to Embodied Carbon Calculation



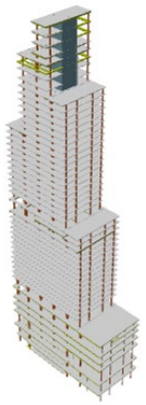

*Reference: Bringing Embodied Carbon Up Front (Source: World Green Building Council)*



# How can we address reducing Embodied Carbon?

# Design and Specification Guidance
## Link to Embodied Carbon Calculation

**Design Guidance**

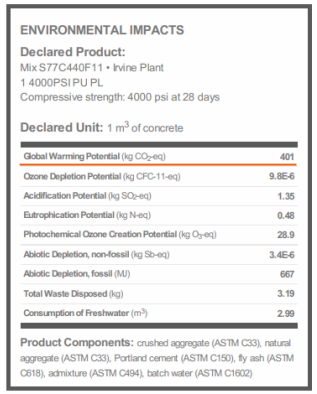


**Quantities of Building Materials**

*From BIM takeoff or hand calculation*

**X**

**Specification Guidance**



ENVIRONMENTAL IMPACTS

**Declared Product:**
Mix S77C440F11 • Irvine Plant
1 4000PSI PU PL
Compressive strength: 4000 psi at 28 days

**Declared Unit:** 1 $m^3$ of concrete

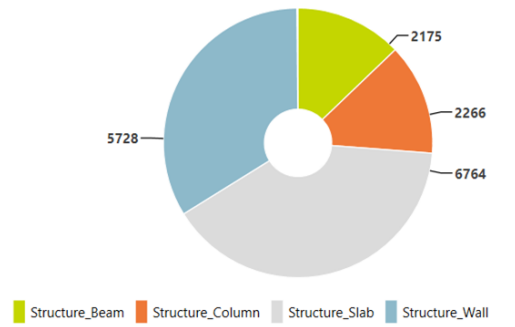
| | |
|---|---|
| Global Warming Potential (kg $CO_2$-eq) | 401 |
| Ozone Depletion Potential (kg CFC-11-eq) | 9.8E-6 |
| Acidification Potential (kg $SO_2$-eq) | 1.35 |
| Eutrophication Potential (kg N-eq) | 0.48 |
| Photochemical Ozone Creation Potential (kg $O_3$-eq) | 28.9 |
| Abiotic Depletion, non-fossil (kg Sb-eq) | 3.4E-6 |
| Abiotic Depletion, fossil (MJ) | 667 |
| Total Waste Disposed (kg) | 3.19 |
| Consumption of Freshwater ($m^3$) | 2.99 |

**Product Components:** crushed aggregate (ASTM C33), natural aggregate (ASTM C33), Portland cement (ASTM C150), fly ash (ASTM C618), admixture (ASTM C494), batch water (ASTM C1602)

**GWP per material**
($kgCO_2e$/unit)

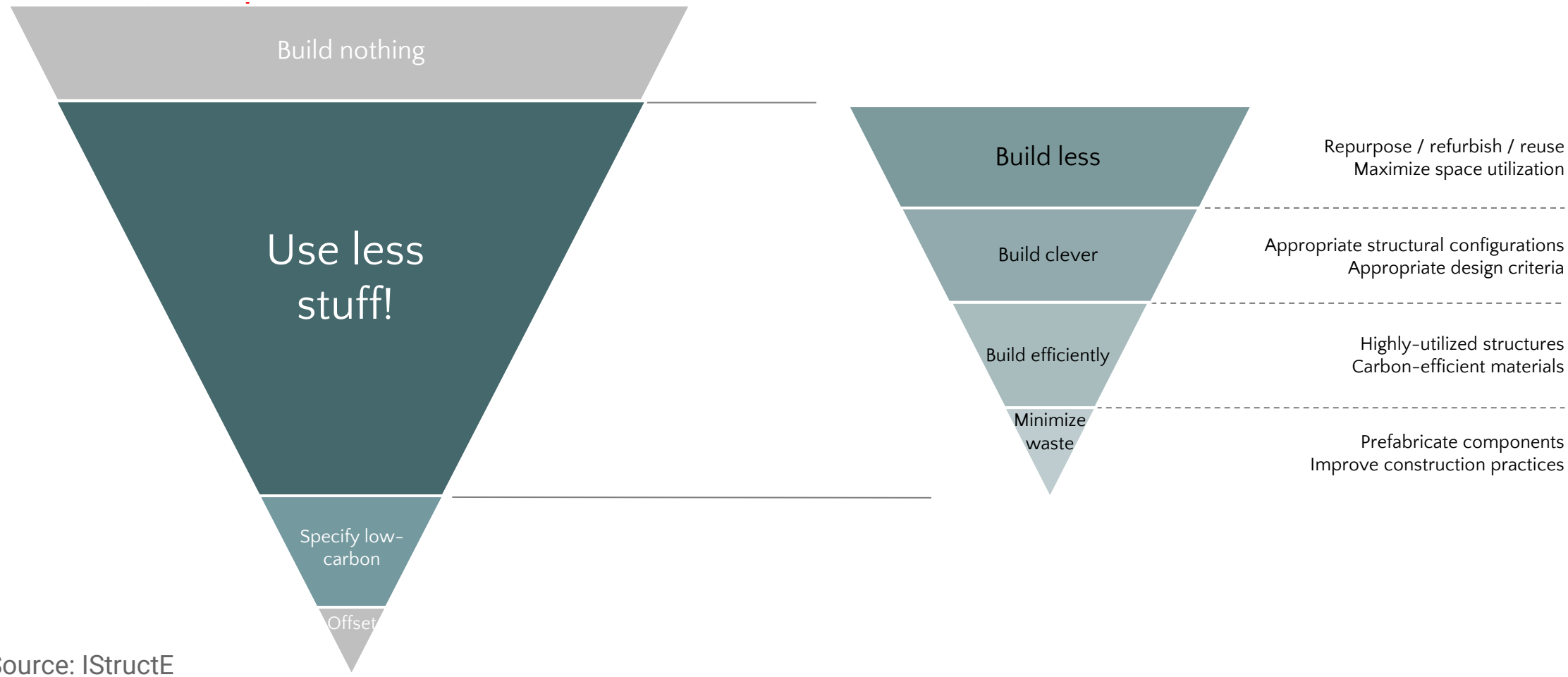
*from Material EPDs or other aggregated data*

**=**



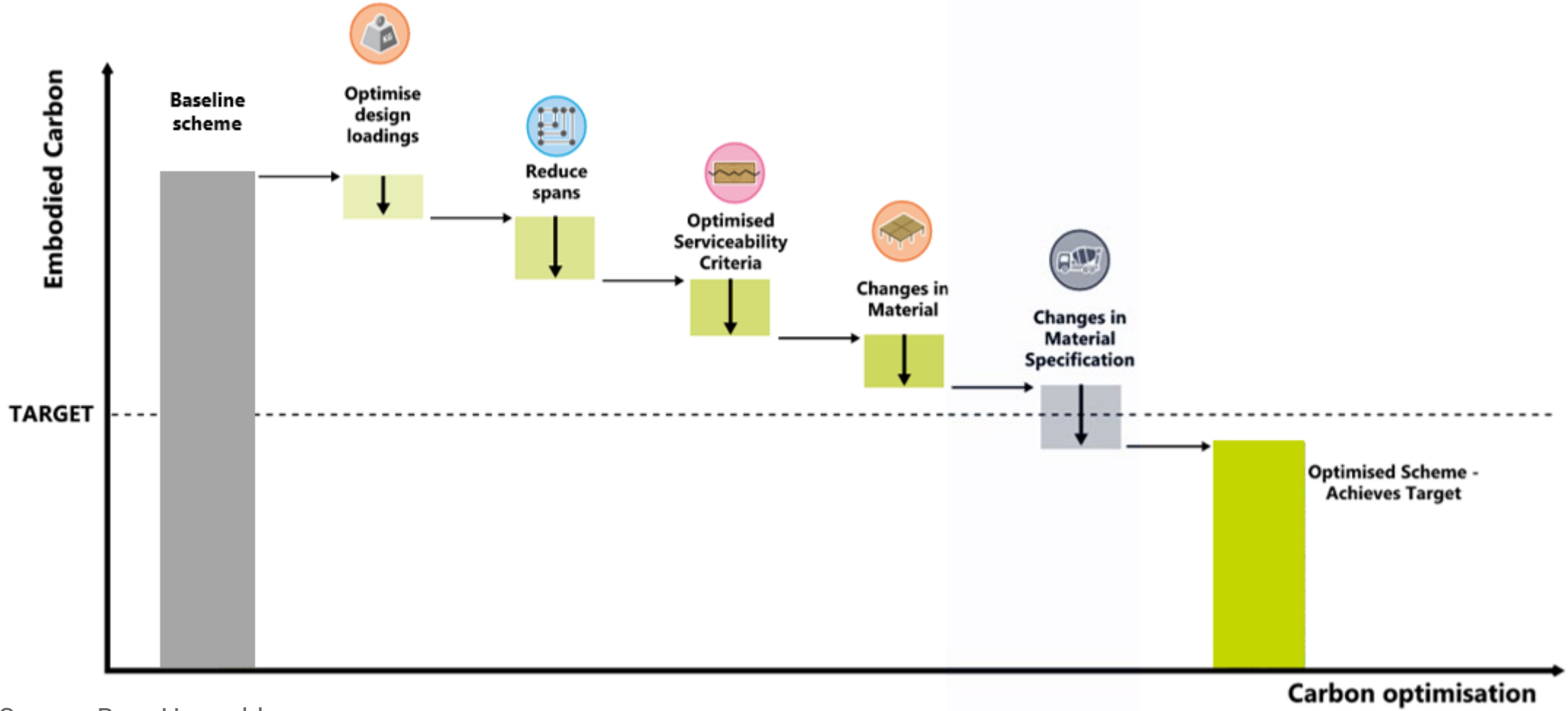

**Whole Building GWP**
($kgCO_2e$)

# **Design Guidance**
# Hierarchy for Reducing Embodied Carbon Emissions




Source: IStructE

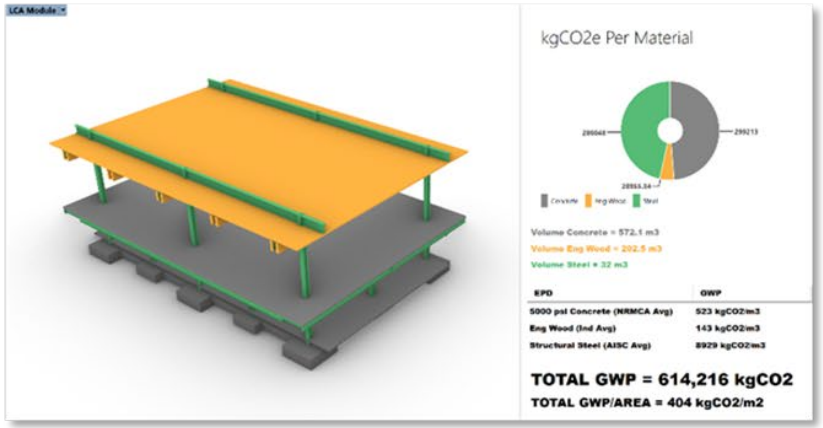
# Design Guidance
## Steps to Improving Material Efficiency




Source: Buro Happold

# Design Optioneering



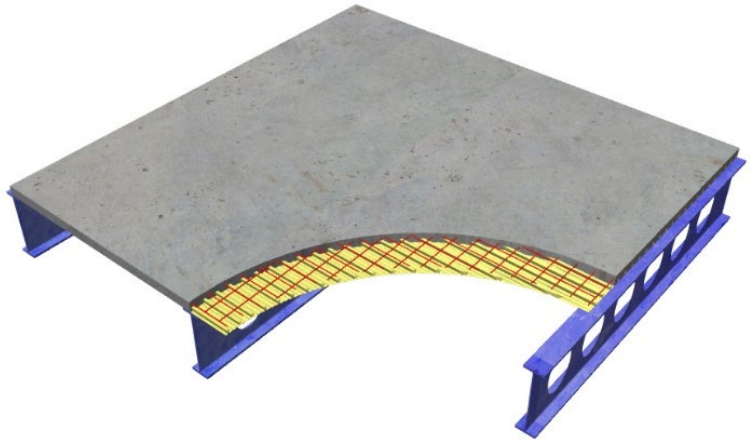




Source: Buro Happold

# Build Light: Composite & Hybrid Floor Systems

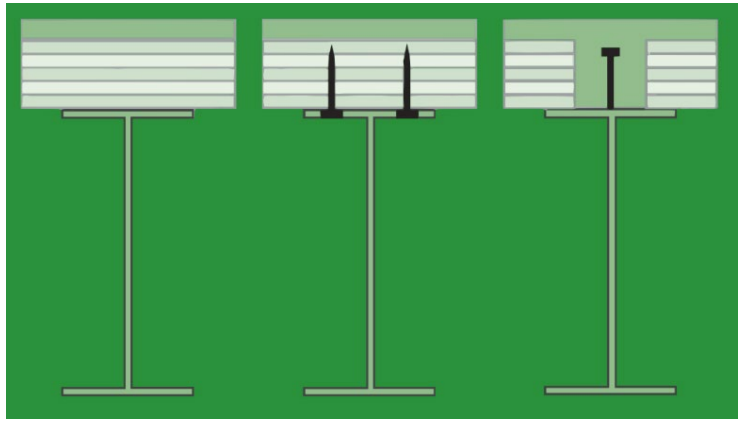
TRADITIONAL COMPOSITE FLOOR SYSTEMS



Source: Buro Happold

Decking systems are engaged with steel framing through shear connectors: thereby reducing required weight of steel framing.

ALTERNATIVE HYBRID FLOOR SYSTEMS

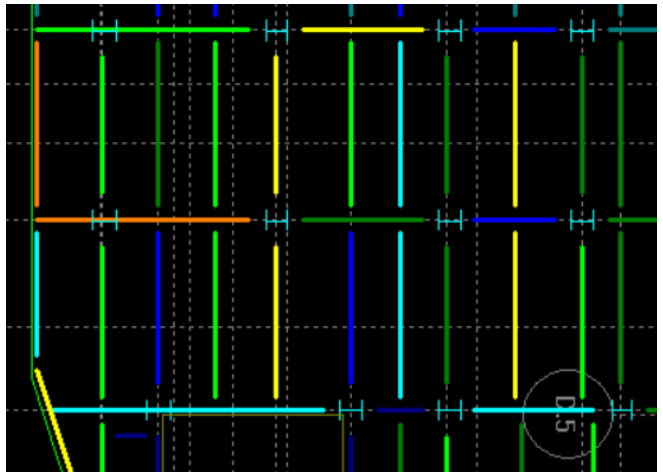


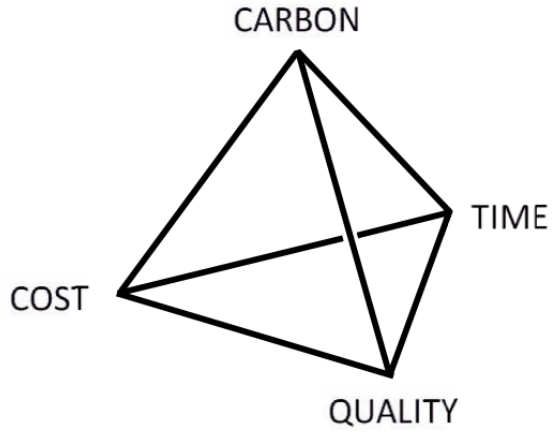
Source: AISC

Timber decking as an alternative to concrete can significantly reduce the embodied carbon of the floor structure.

# Design Methods: Utilization & Optimization

- Be aware of compounding safety factors
- Avoid the application of maximum utilization ratios below 1.0 during final design, particularly for floor members.
- Avoid rationalization methods, such as enveloping member demands, which may lead to some elements being particularly underutilized.
- Consider the application of material strengths:
- Higher strength materials for strength-controlled members
- Lower strength materials for serviceability-controlled members
- Use structural optimization methods
  - Size optimization: lightest sections available to meet criteria set by the engineer
  - Shape optimization: structural members may be shaped to use material where it is most needed
  - Topology optimization: topology or layout of a minimum-volume structure under given loading, support, and serviceability conditions.

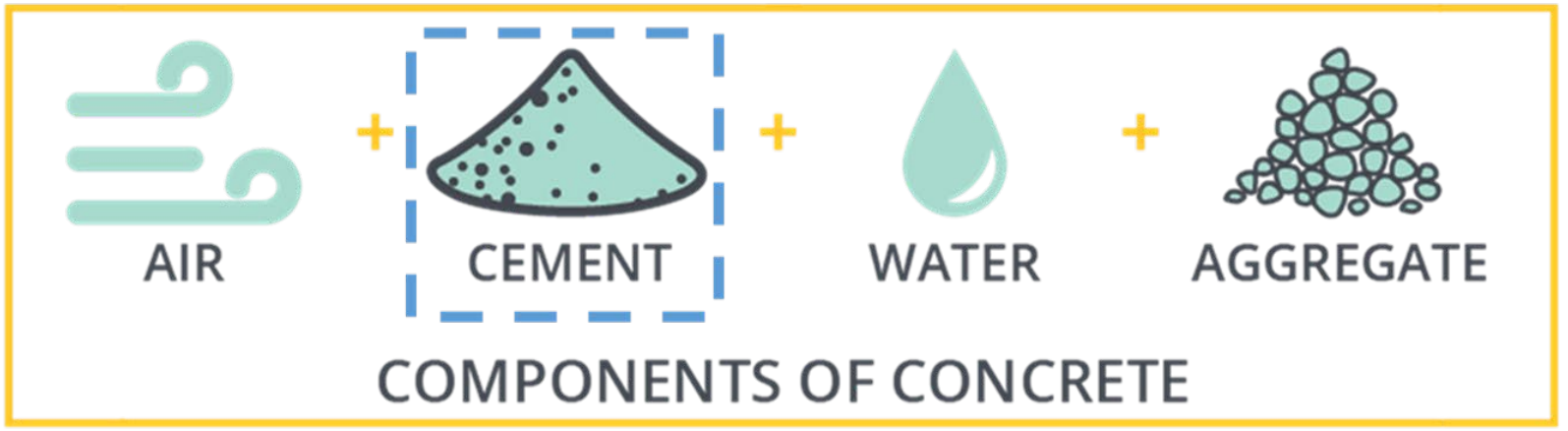




# Specifications Guidance

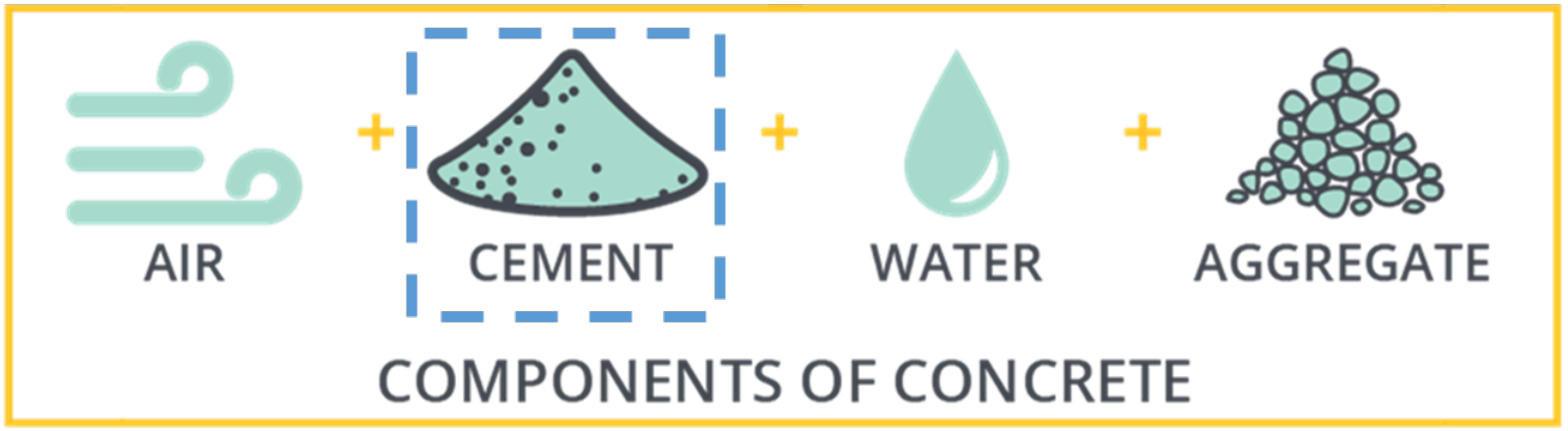

- Curated list of strategies to write lower embodied carbon specification documents
- Topics include:
  - Requesting product-specific EPDs
  - Performance specifications
  - GWP limits
  - Material-specific guidance (concrete, steel, wood, CMU)

# Concrete



# Concrete

**7 to 15%**
**concrete volume**




**95% carbon emissions**

# Performance-Based Concrete Spec

- Starting point to communicate with GC and suppliers
- Remove overly prescriptive limits
- Carbon budget approach

## Concrete Class Table

| Intended Use | Compressive Strength f'c (psi), at 28 days, uno | Exposure Class | | | | Maximum w/cm ratio | Maximum Aggregate Size | Target Air Content | Global Warming Potential Target (kgCO2e/yd3) | Other Design Requirements |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | S | W | C | | | | | |
| Drilled Piers | 4000psi NWC at 56 days | F0 | S0 | W0 | C0 | – | 1 1/2" | – | 240 | The design requirements provided in this example are the minimum recommended criteria for all projects. See the description of additional concrete properties on the next page for additional information. Add additional columns as needed for project specific conditions. |
| Spread Footings | 4000psi NWC at 56 days | F0 | S0 | W0 | C0 | – | 1 1/2" | – | 240 | |
| Foundation Walls | 4000psi NWC at 56 days | F0 | S0 | W0 | C0 | – | 3/4" | – | 240 | |
| Grade Beams and Stem Walls | 4500psi NWC at 56 days | F2 | S0 | W1 | C1 | 0.45 | 3/4" | 6% | 290 | |
| Core, Shear and Bearing Walls | 5000psi NWC at 56 days | F0 | S0 | W0 | C0 | – | 3/4" | – | 290 | |
| Interior SOG | 3000psi NWC at 56 days | F0 | S0 | W0 | C0 | – | 1" | – | 205 | |
| Exterior/ Garage SOG | 5000psi NWC at 56 days | F3 | S0 | W1 | C2 | 0.40 | 1" | 6% | 330 | |
| Interior PT Elevated Slab | 5000psi NWC at 28 days (3000psi at stressing) | F0 | S0 | W0 | C0 | – | 3/4" | – | 429 | |
| Exterior/ Garage PT Elevated Slab | 5000psi NWC at 28 days (3000psi at stressing) | F3 | S0 | W1 | C2 | 0.40 | 3/4" | 6% | 429 | |
| Columns | 7000psi NWC at 28 days | F0 | S0 | W0 | C0 | – | 3/4" | – | 490 | |
| Interior Non - PT Elevated Slab | 5000psi NWC at 28 days | F0 | S0 | W0 | C0 | – | 3/4" | – | 330 | |
| Exterior/ Garage Non - PT Elevated Slab | 5000psi NWC at 28 days | F3 | S0 | W1 | C2 | 0.40 | 3/4" | 6% | 330 | |



**Notes:**

1. Concrete proportioning and requirements must comply with ACI 318-19 Tables 19.3.1.1, 19.3.2.1, 19.3.3.1 and 26.4.2.2(b) in addition to the requirements of this table.
2. Global warming potential (GWP) targets as shown have been established as part of the sustainable design requirements for the project and are intended to be maximum values.

# What is Changing?


BREAKING NEWS
CALIFORNIA WILDFIRES DEATH TOLL RISES TO AT LEAST 31
NIGHTLY NEWS

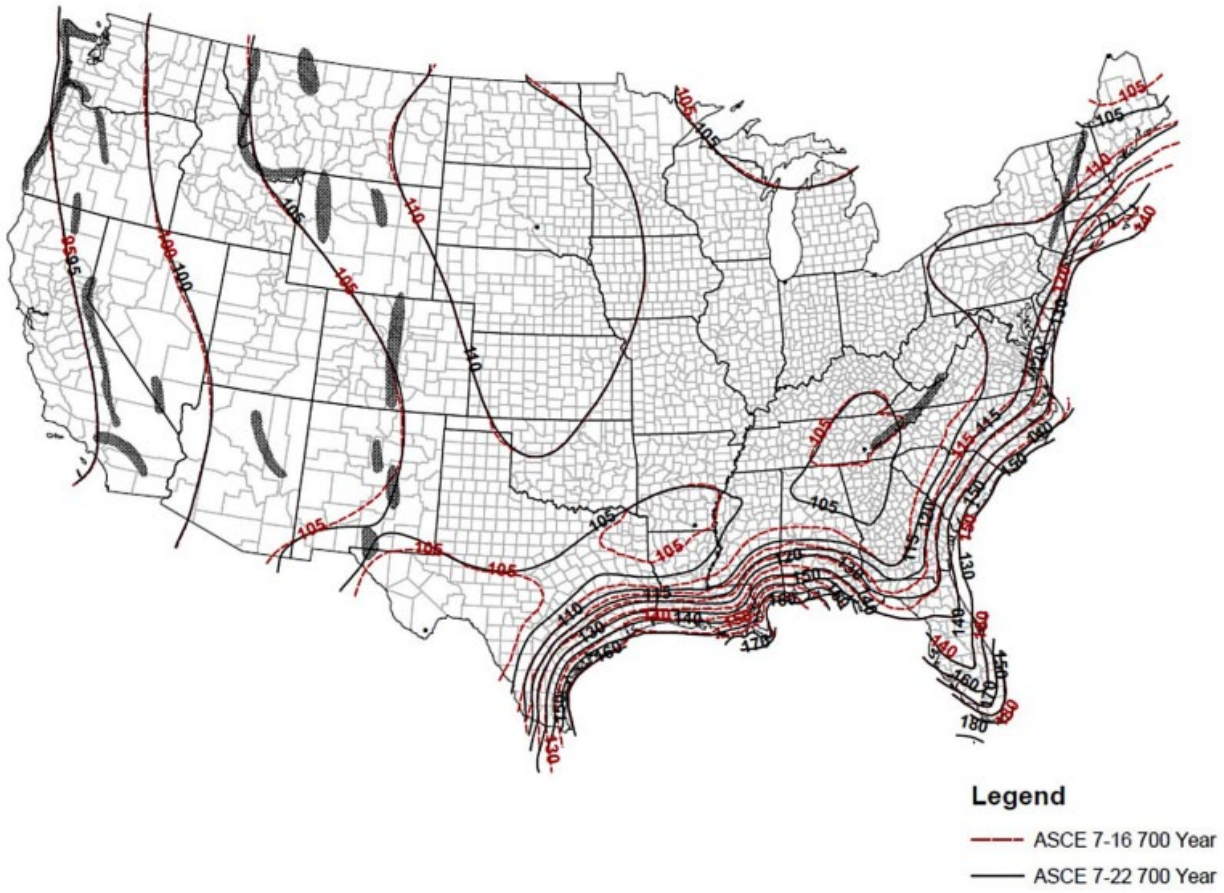

CEDAR KEY, FL
FRIDAY
FOX NEWS
HELENE CAUSES AT LEAST $15B IN PROPERTY DAMAGE
FOX WEATHER ALERT
HURRICANE HQ
STREAM
FOX WEATHER


HURRICANE HARVEY
TRACKING THE STORM
Schulenburg
Houston
San Antonio
Galveston
Bay City
Victoria
Port Lavaca
Three Rivers
Rockport
Corpus Christi
NBC NEWS SPECIAL REPORT
LIVE
HURRICANE HARVEY MAKES LANDFALL AS CAT 4
130 MPH WINDS AND HEAVY RAINS LASH TEXAS COAST


Statesman Journal
'Oppressive' heat
CARES Act fuels county efforts
The Province
KILLER HEAT
Portland hits 112, Monday hotter still
LEWISTON TRIBUNE
Lewiston sees third-hottest day ever
NOW IT'S REALLY HEATING UP
Century-old city heat record falls
TRUCKING IN RELIEF

FEMA Fact Sheet

# Highlights of Significant Changes to the Wind Load Provisions of ASCE 7-22




(Source: Adapted from Figure 26.5-1B of ASCE 7-16 and Figure 26.5-1B of ASCE 7-22 with permission)

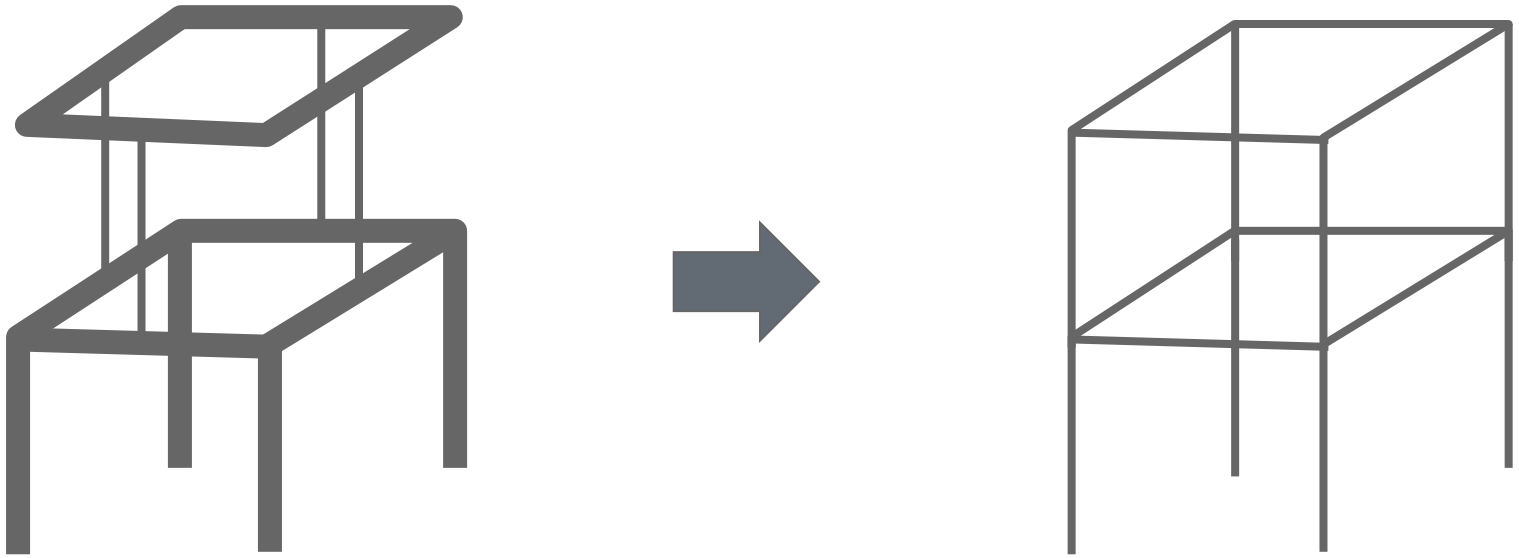
**Figure 1: Comparison of basic wind speeds for Risk Category II buildings and structures in ASCE 7-16 and ASCE 7-22**

# CLF Policy Map


- Buy Clean
- WBLCA Performance
- Building Reuse

Seeds of Opportunity

# Save Cost through Efficiency



Save Cost
through Efficiency

Seeds of Opportunity

# Add Value to Existing Buildings

Save Cost through Efficiency

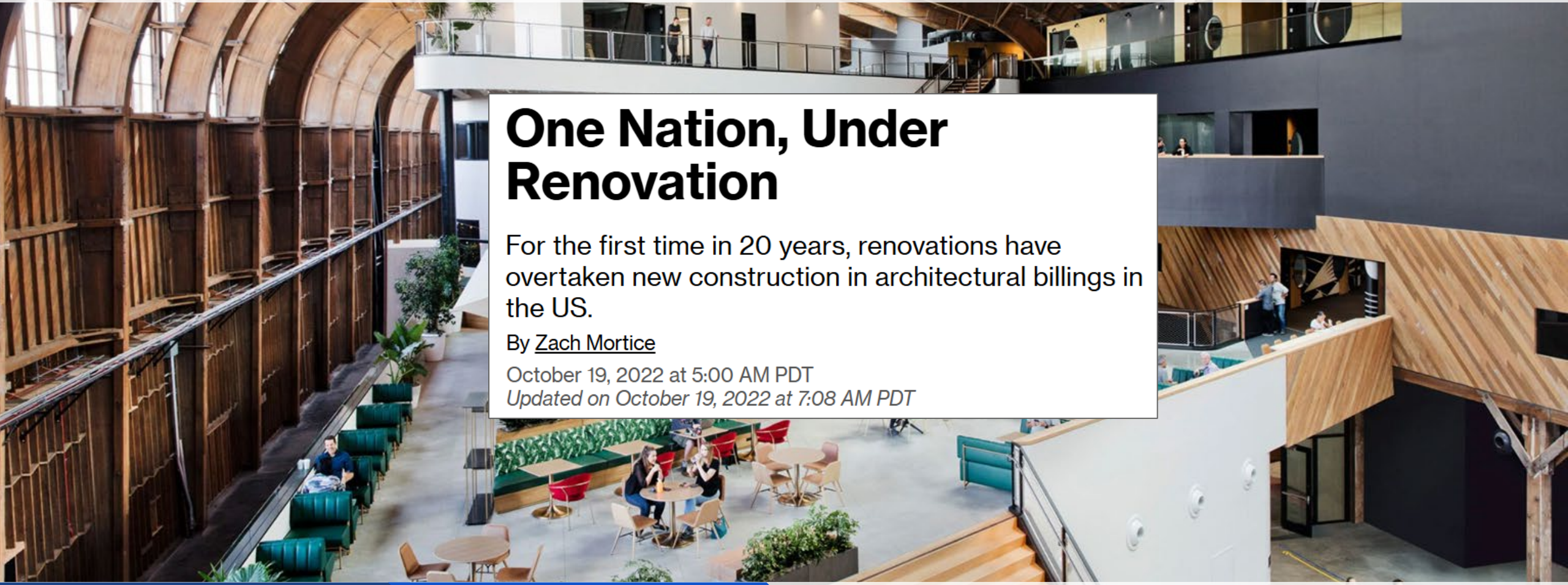
Add Value to Existing Buildings

**“Spruce Goose”, Los Angeles**

ZGF ARUP

Seeds of Opportunity

# Add Value to Existing Buildings



## One Nation, Under Renovation

For the first time in 20 years, renovations have overtaken new construction in architectural billings in the US.

By Zach Mortice

October 19, 2022 at 5:00 AM PDT
*Updated on October 19, 2022 at 7:08 AM PDT*

Save Cost through Efficiency

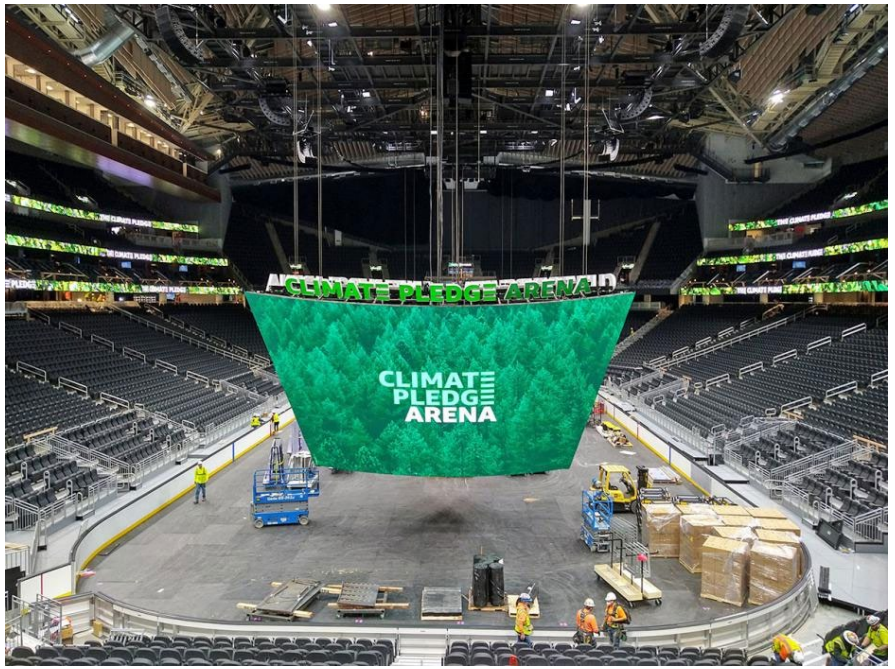
Add Value to Existing Buildings

"Spruce Goose", Los Angeles

ZGF ARUP

Seeds of Opportunity

# Market the Wins



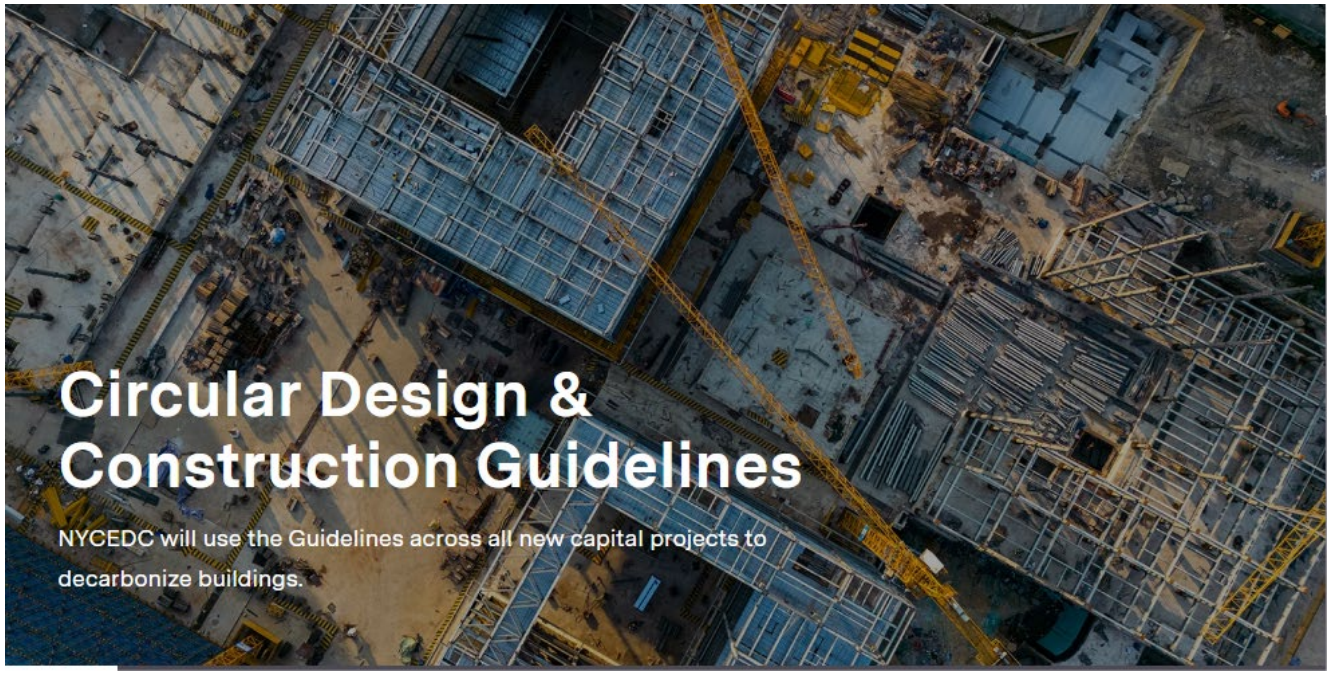

Save Cost through Efficiency

Add Value to Existing Buildings

Market the Wins

Seeds of Opportunity

# Recover Materials for Reuse




Save Cost through Efficiency

Add Value to Existing Buildings

Market the Wins

Recover Materials for Reuse


Alexis Feitel
KL&A




Carbon Leadership Forum Rocky Mountain x Los Angeles
June 11th, 2024

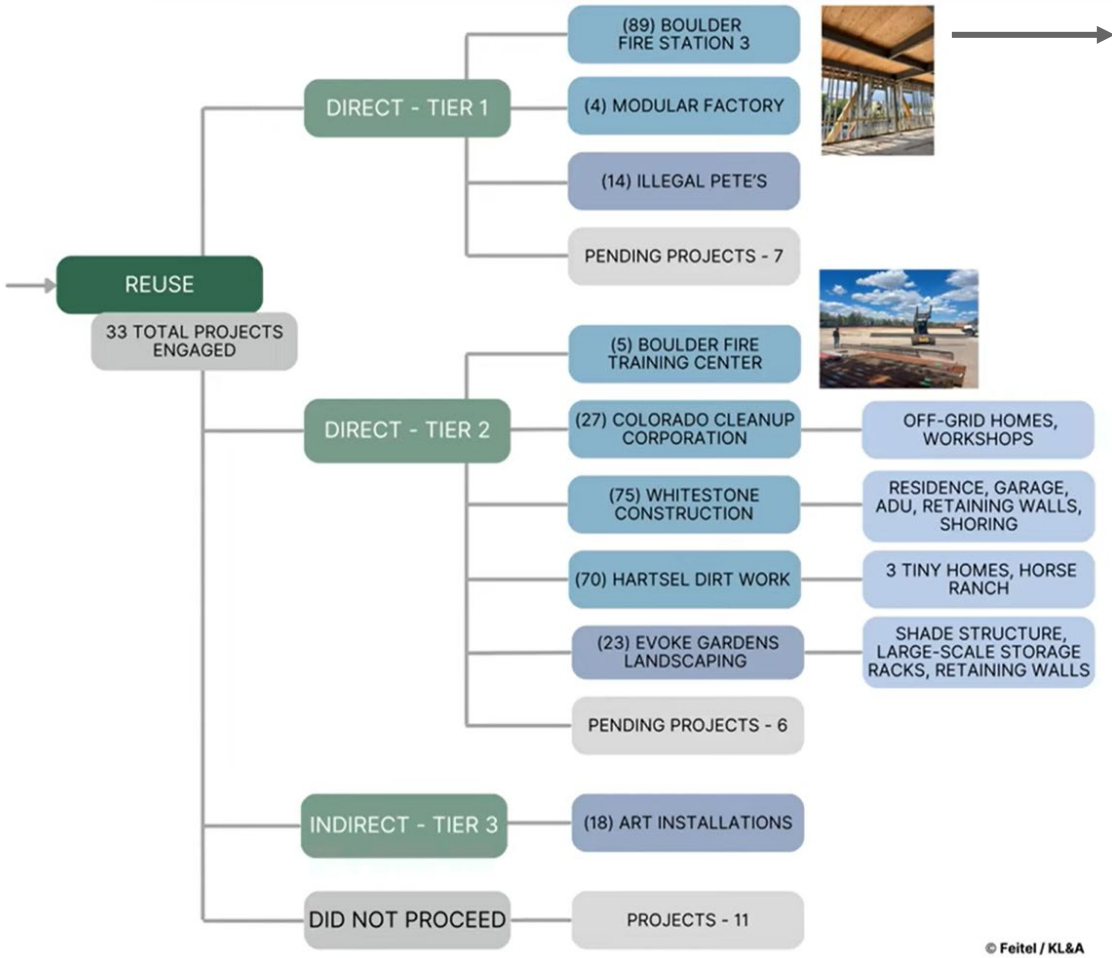
# Boulder Community Hospital

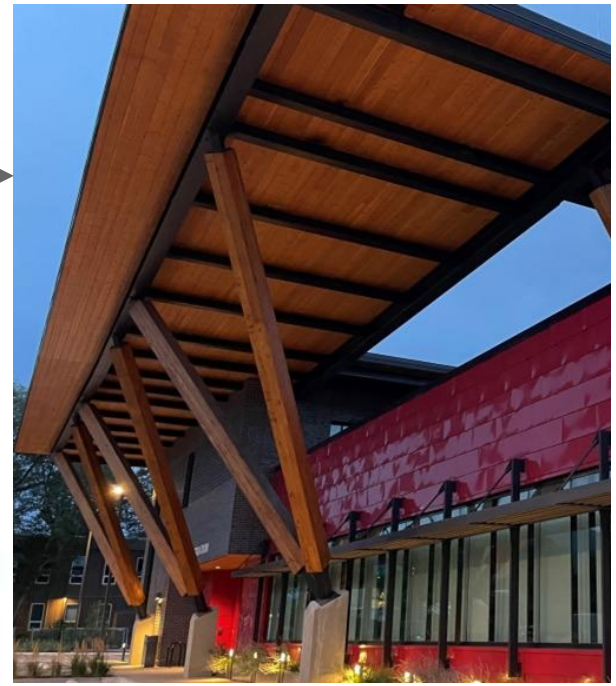
## Deconstruction, Stockpiling, and Reuse of Structural Steel


Alexis Feitel, P.E.
Team Carbon Unit Director & BCH Project Manager afeitel@klaa.com


KL&A
Engineers & Builders

# PROJECT – MATERIAL MAP



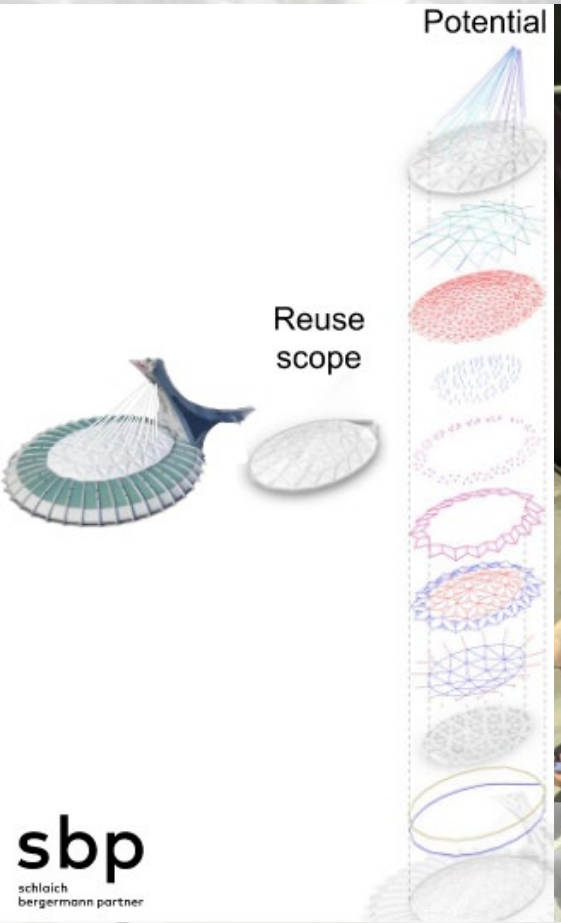
KL&A
Engineers & Builders

# Dan Bergsagel
## Schlaich Bergermann Partner

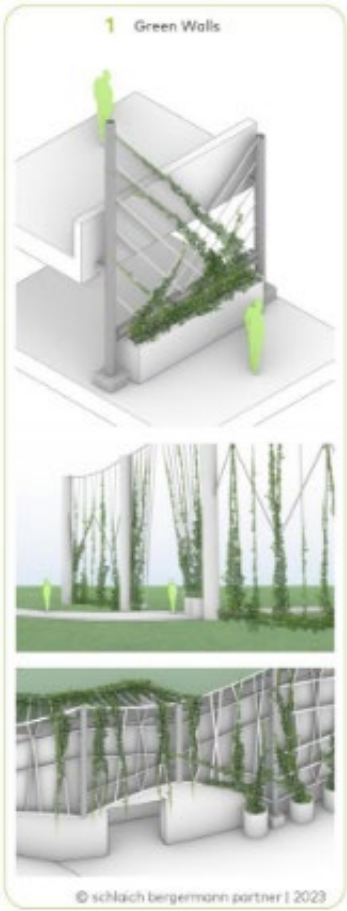
Montreal Olympic Stadium (1999)

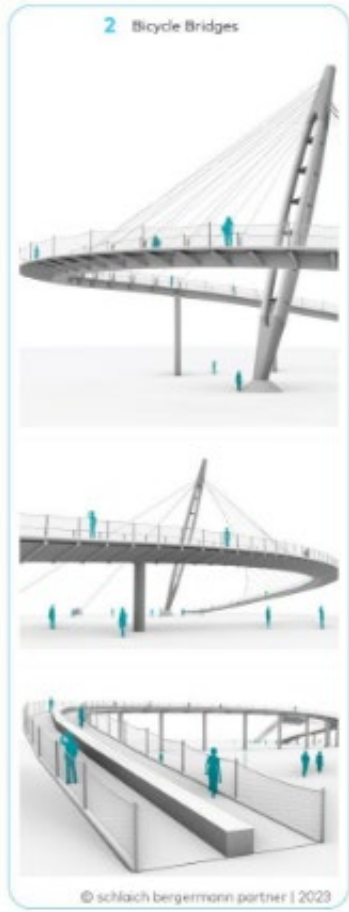
sbp
schlaich
bergermann partner

# Envisioning the Future of Structural Engineering









sbp
schlaich bergermann partner

Montreal Olympic Stadium (1999)

*“I’d be a pessimist but it would never work.”*

# WHAT CAN I DO?

- Join the SE 2050 Commitment Program
- Ask to be included in a project's sustainability meetings and design charrettes
- Advocate within industry and to your clients!


**Towards Zero Carbon: Developing a Roadmap for the Structural Engineering Profession and SEI**

*ASCE an SEI Workshop held July 23-24, 2024 at Northeastern University*


**Towards Zero Carbon: Developing a Roadmap for the Structural Engineering Profession and SEI**

*ASCE an SEI Workshop held July 23-24, 2024 at Northeastern University*

# Questions?

Luke Lombardi, P.E.
luke.lombardi@burohappold.com

STRUCTURAL ENGINEERING INSTITUTE

SE2050
COMMITTING TO NET ZERO

**Are you ready to join the movement?**

https://se2050.org/sign-up/

# THANK YOU!

# SLIDE APPENDIX

*Engineering is the art of*
*modelling materials we do not wholly understand,*
*into shapes we cannot precisely analyse,*
*so as to withstand forces we cannot properly assess,*
*in such a way that the public has no reason*
*to suspect the extent of our ignorance.*

**-- Dr. A. R. Dykes, British Institution of Structural Engineers**

# TEST YOUR KNOWLEDGE:


A project has a total of 100 concrete trucks delivered to site.

The project has achieved a 20% carbon reduction in the concrete mix.

# TEST YOUR KNOWLEDGE:

**Approximately how many New York to Los Angeles flights would need to be avoided by one person in order to achieve the same carbon savings as the project?**

- 5 flights
- 10 flights
- 25 flights
- 50 flights

# TEST YOUR KNOWLEDGE:

**Approximately how many New York to Los Angeles flights would need to be avoided by one person in order to achieve the same carbon savings as the project?**

- 5 flights
- 10 flights
- 25 flights
- 50 flights

# EMBODIED CARBON INTENSITY DIAGRAMS

# EMBODIED CARBON INTENSITY DIAGRAMS (ECIDs)

**Intent:** Start to establish fluency in EC metric

**Objective:** Using a set of criteria, engineers were tasked with designing a “typical bay”

**Tools:**

- Athena IE
- tallyLCA
- One Click LCA

**Scope:**

- Cradle-to-Grave (Life Cycle Stages A-C)
- Cradle-to-Cradle (Life Cycle Stages A-D)

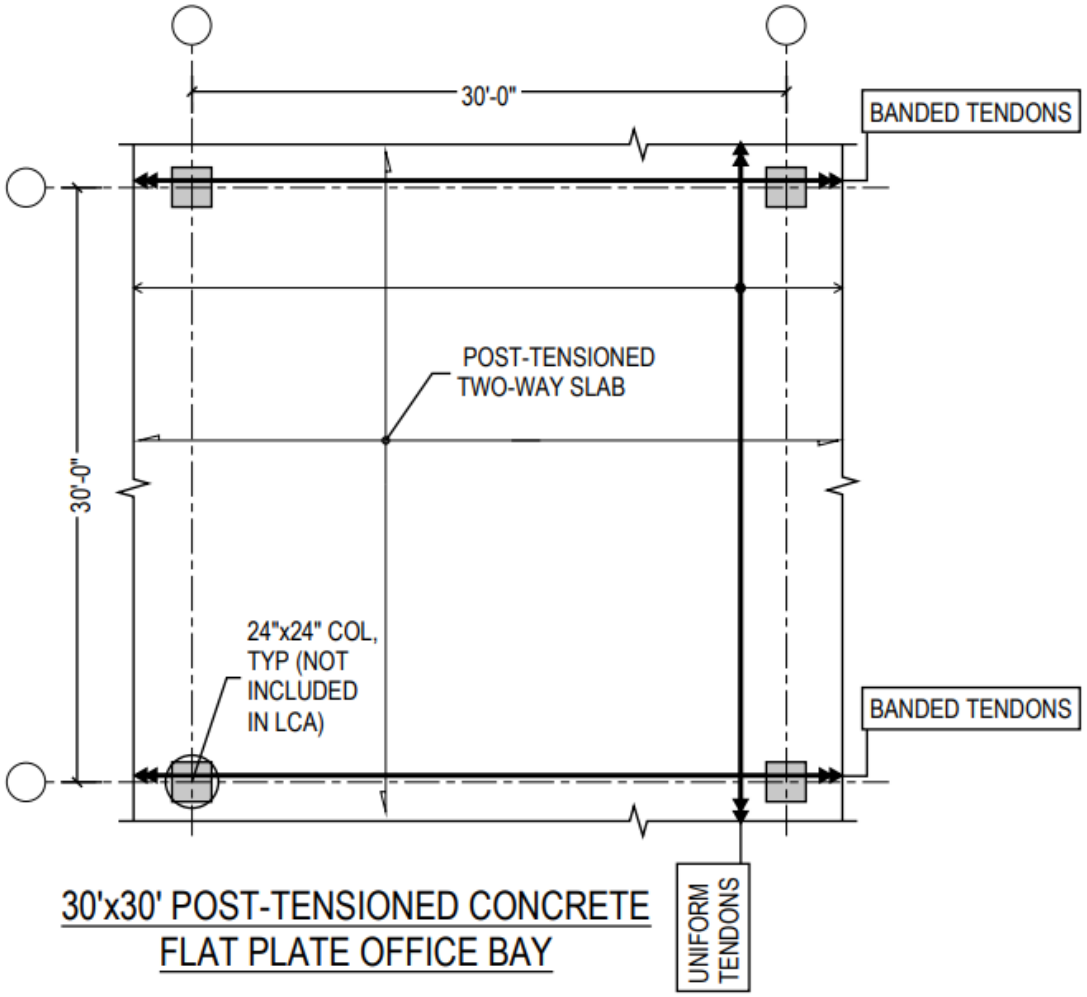
**Office Bays**

- PT Concrete
- Concrete Joist
- Composite Steel
- Hybrid Timber & Steel
- Timber (Post & Beam)

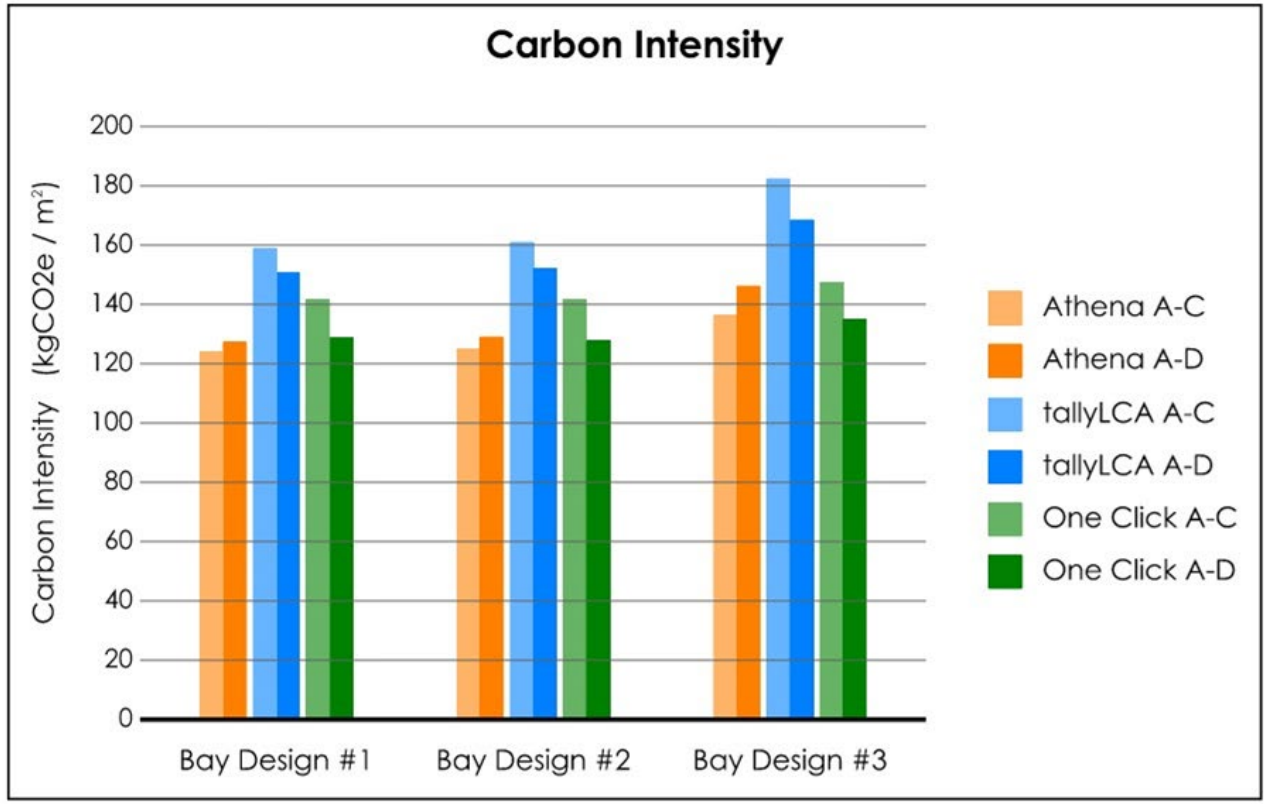
**Residential Bays**

- Mild Concrete
- Light-Framed Wood

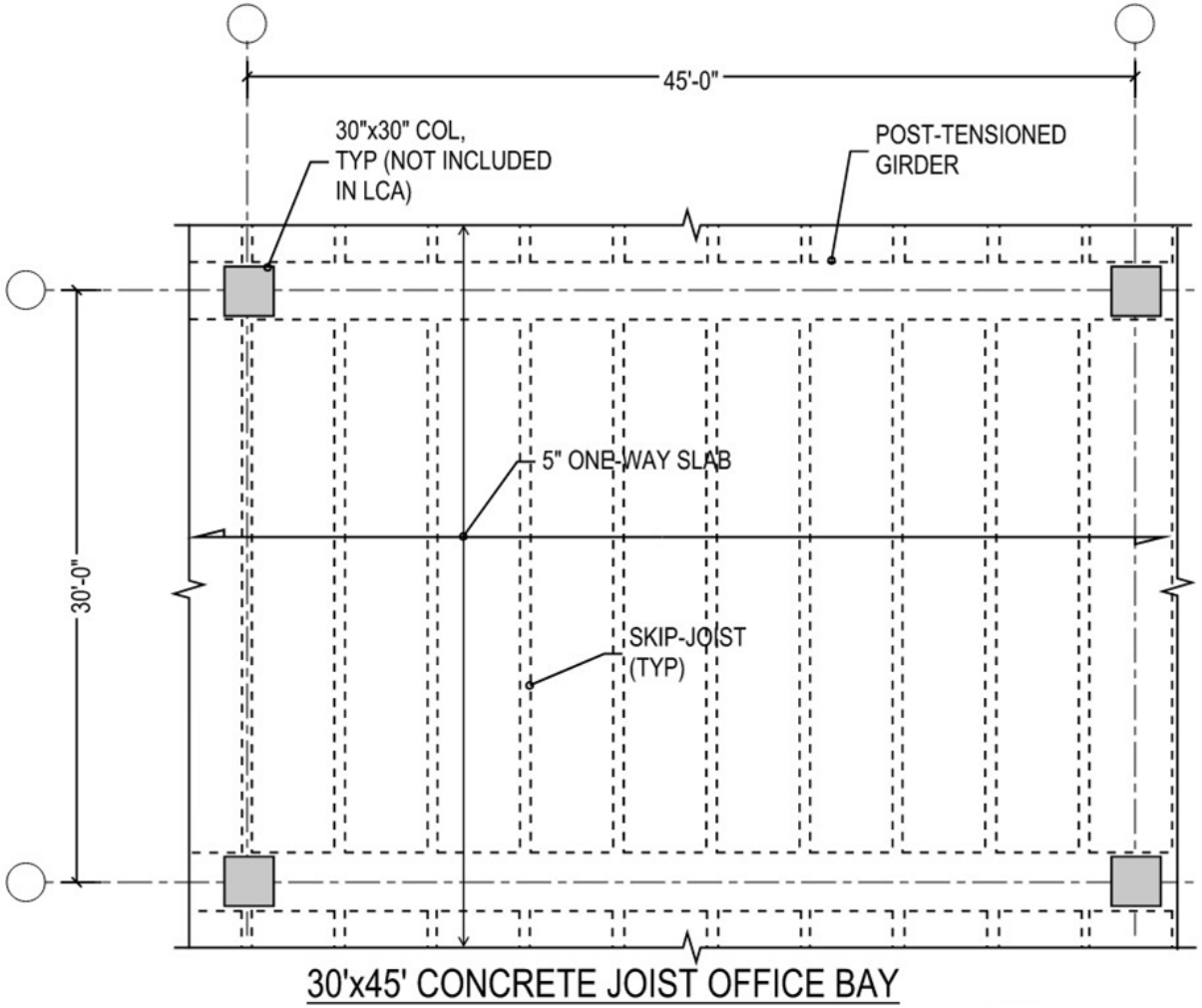
# POST-TENSIONED CONCRETE FLAT PLATE OFFICE ECID

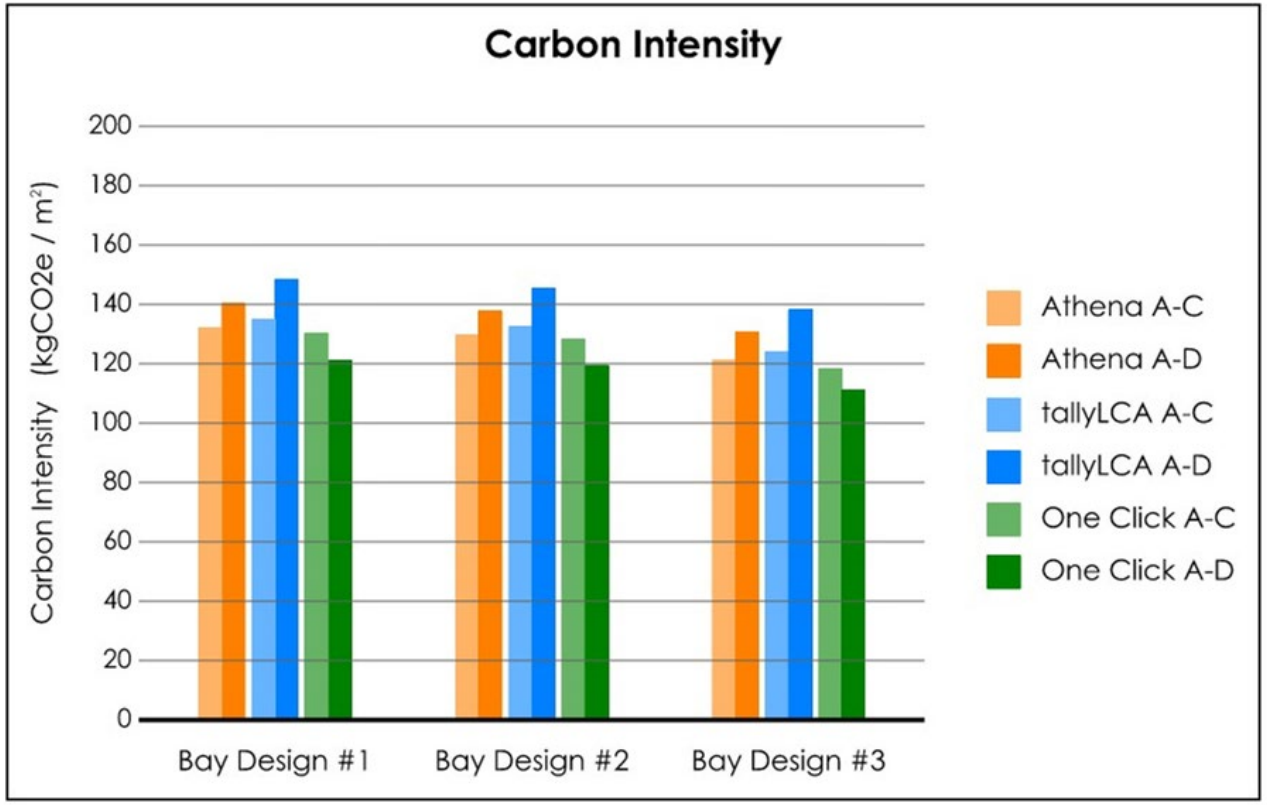



30'x30' POST-TENSIONED CONCRETE FLAT PLATE OFFICE BAY

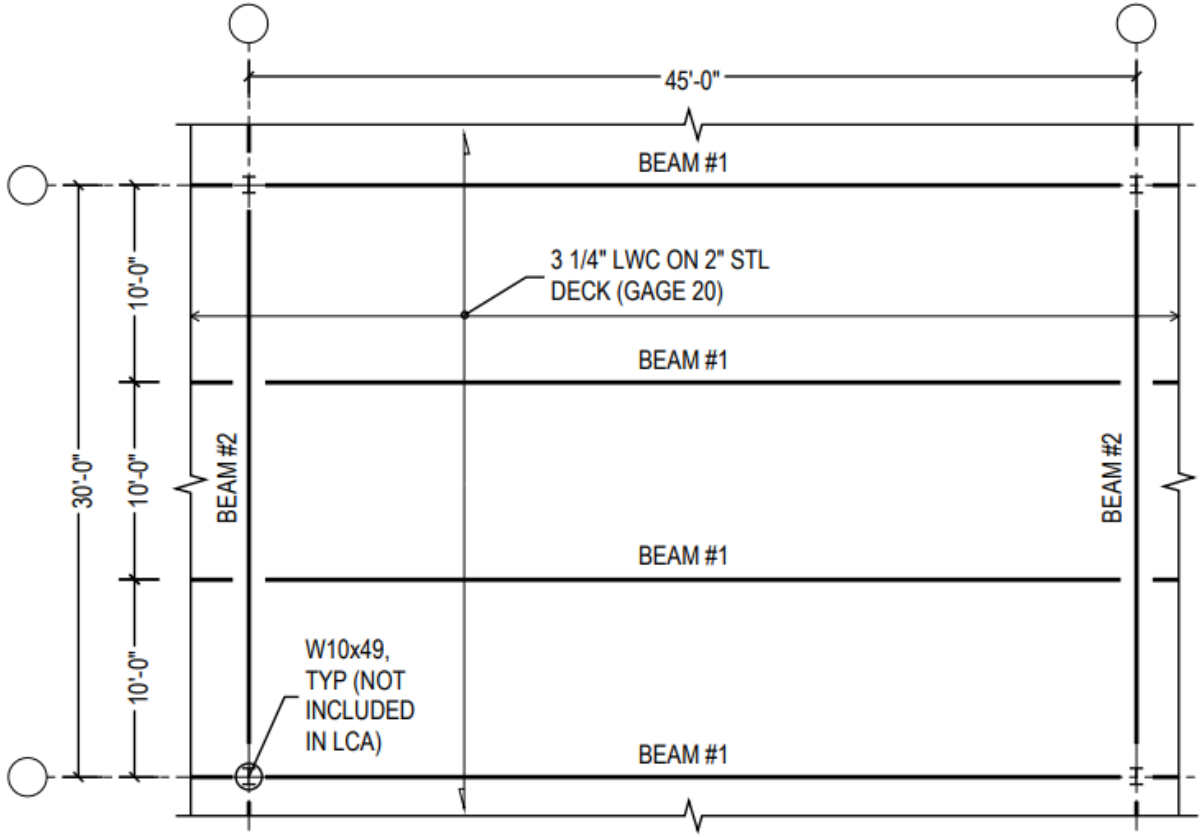


# CONCRETE JOIST OFFICE ECID

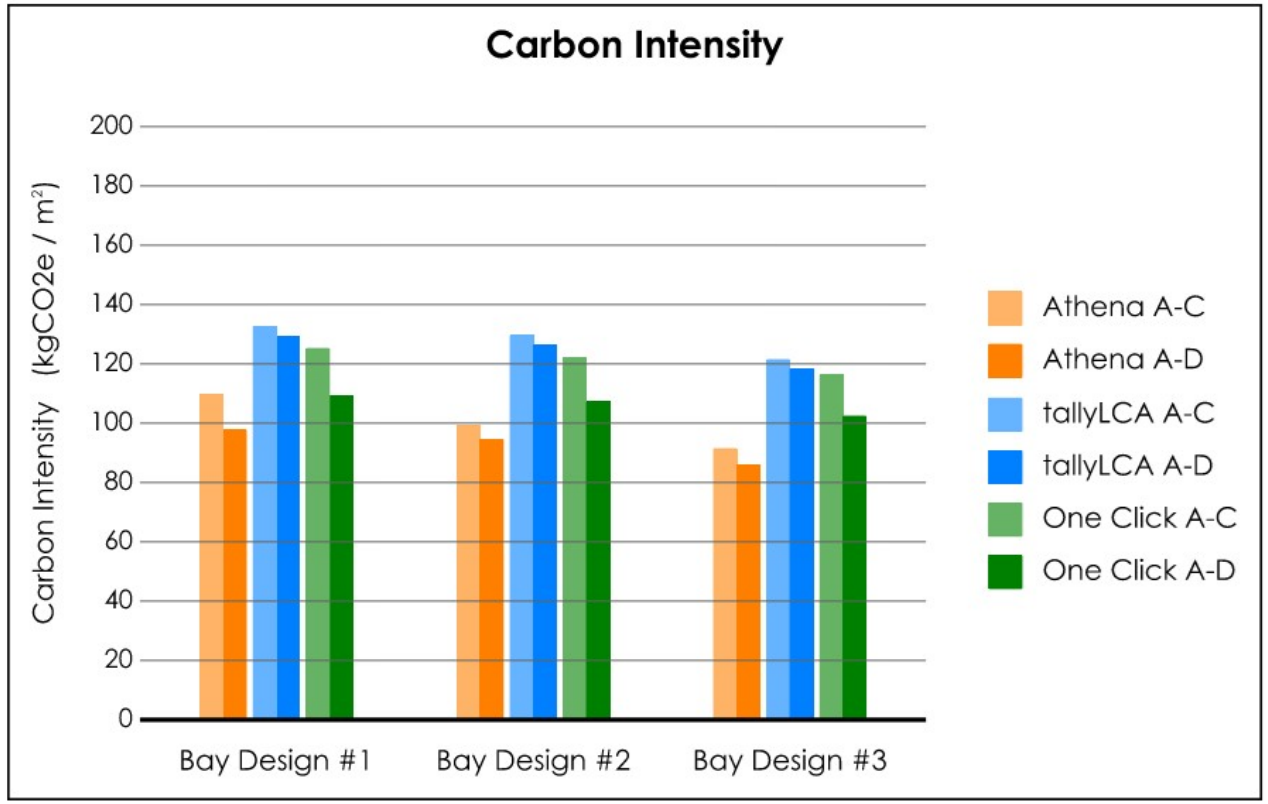


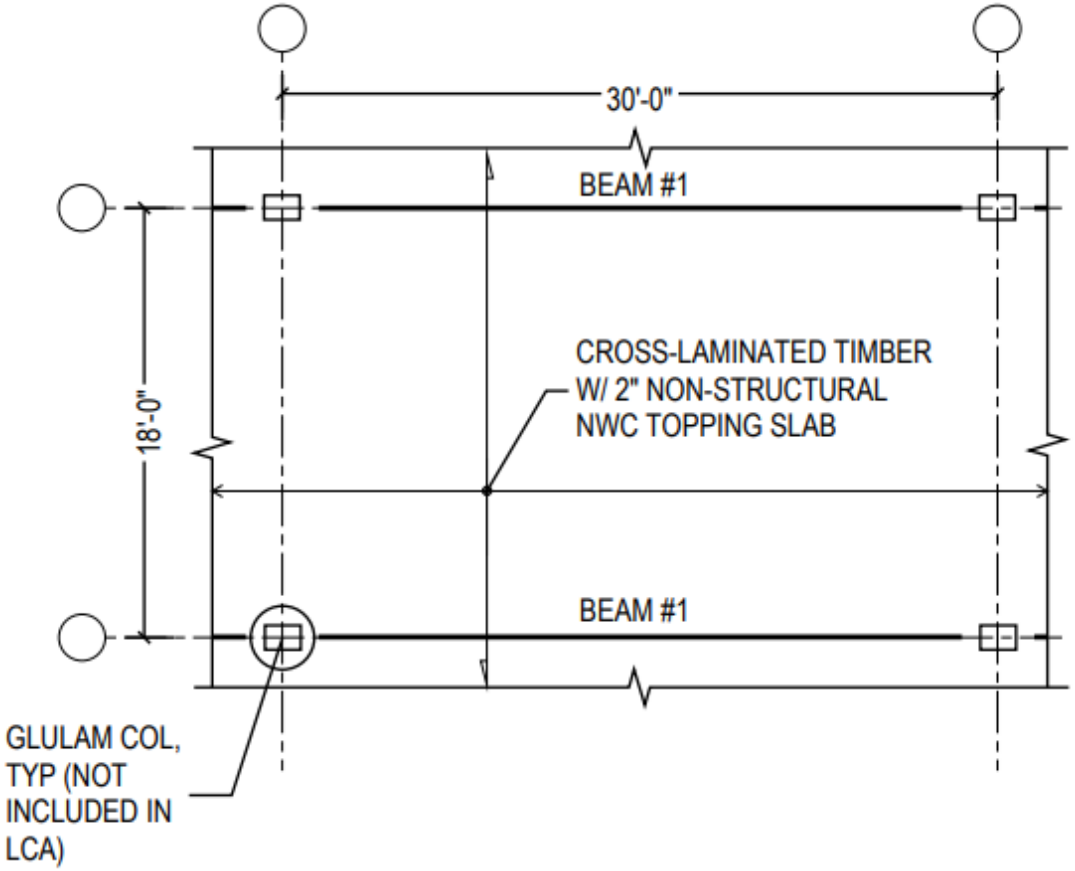
# COMPOSITE STEEL OFFICE ECID



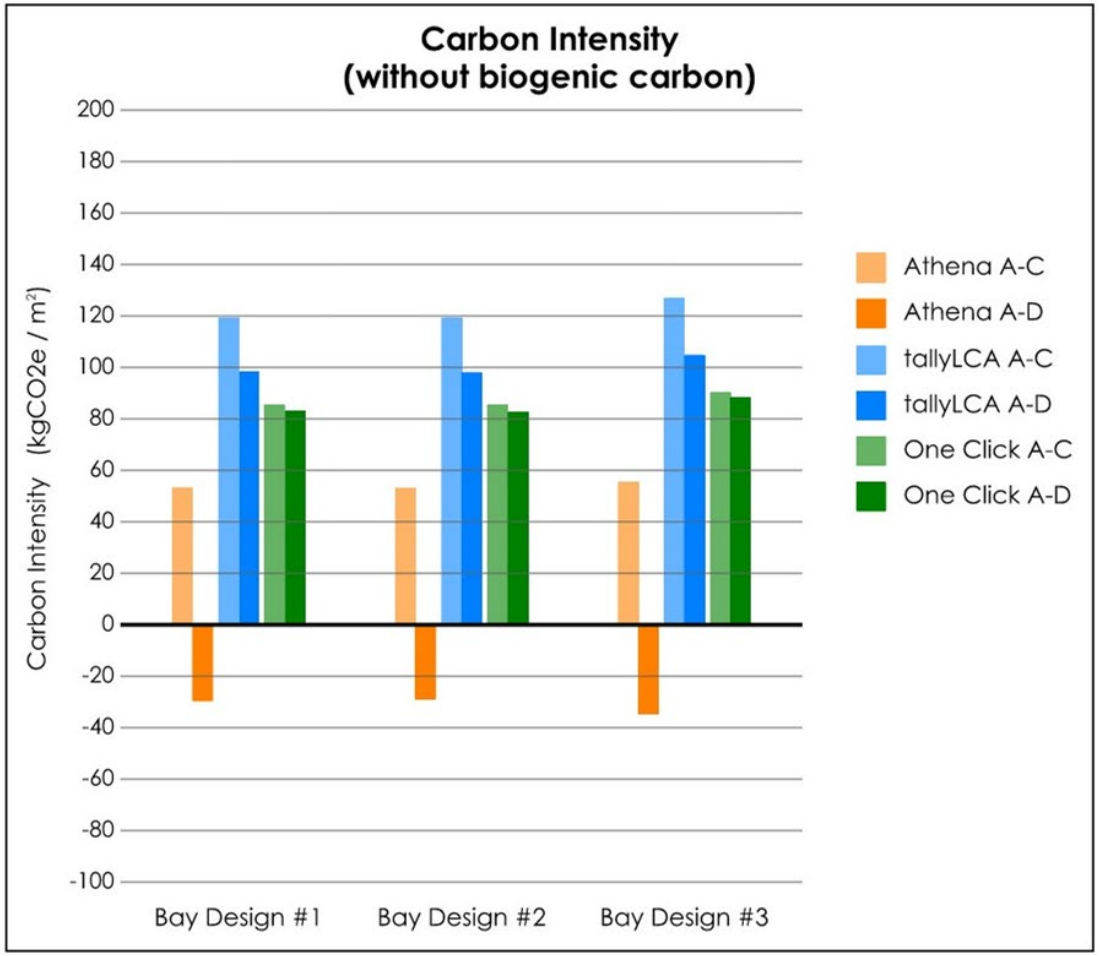

30'x45' COMPOSITE STEEL OFFICE BAY



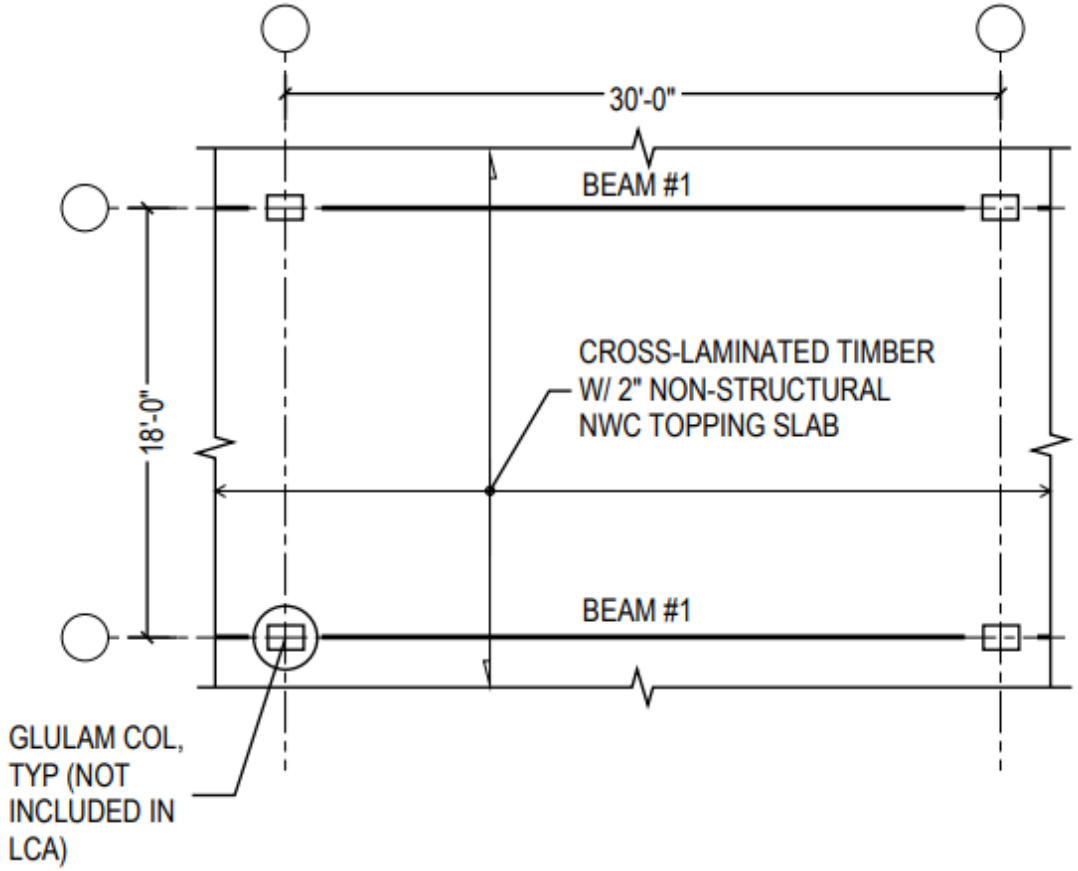
# MASS TIMBER POST-AND-BEAM OFFICE ECID



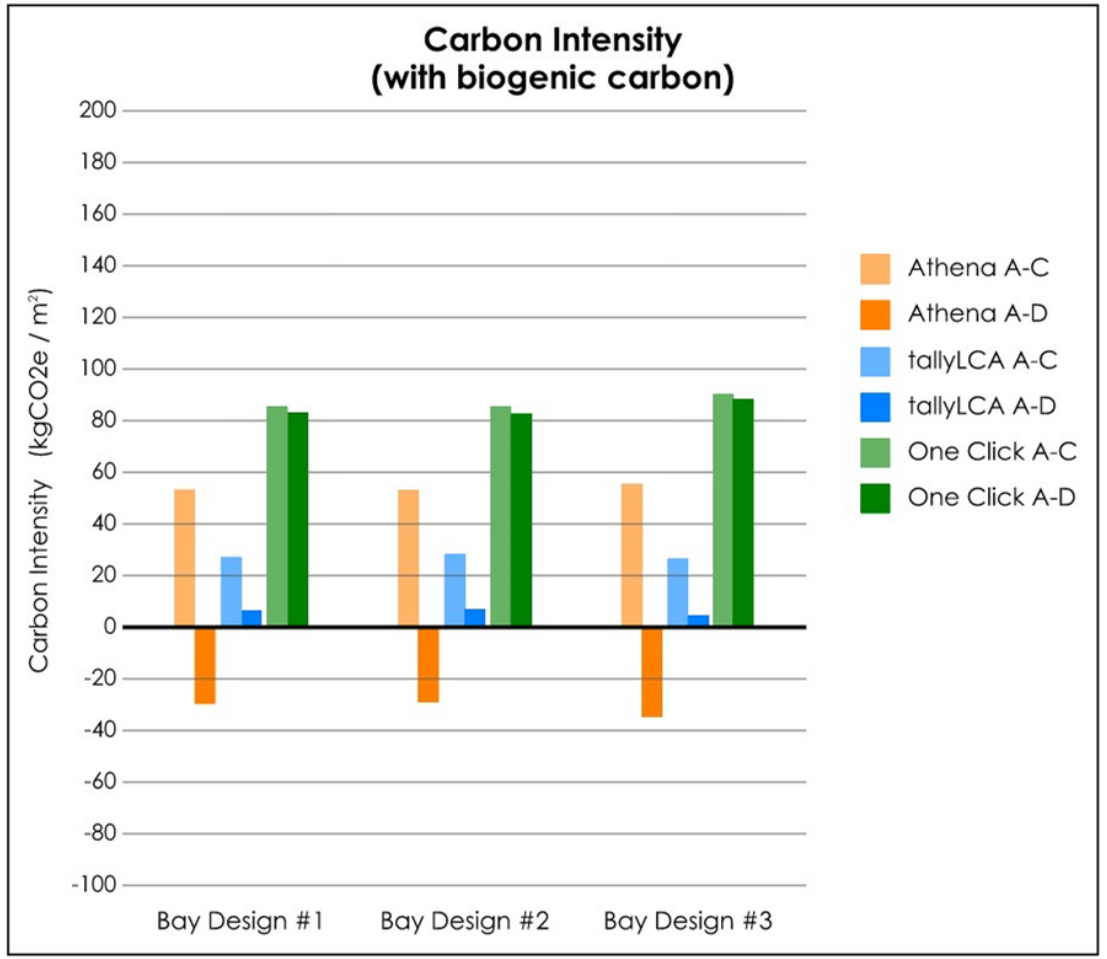

18'x30' MASS TIMBER
POST-AND-BEAM OFFICE BAY



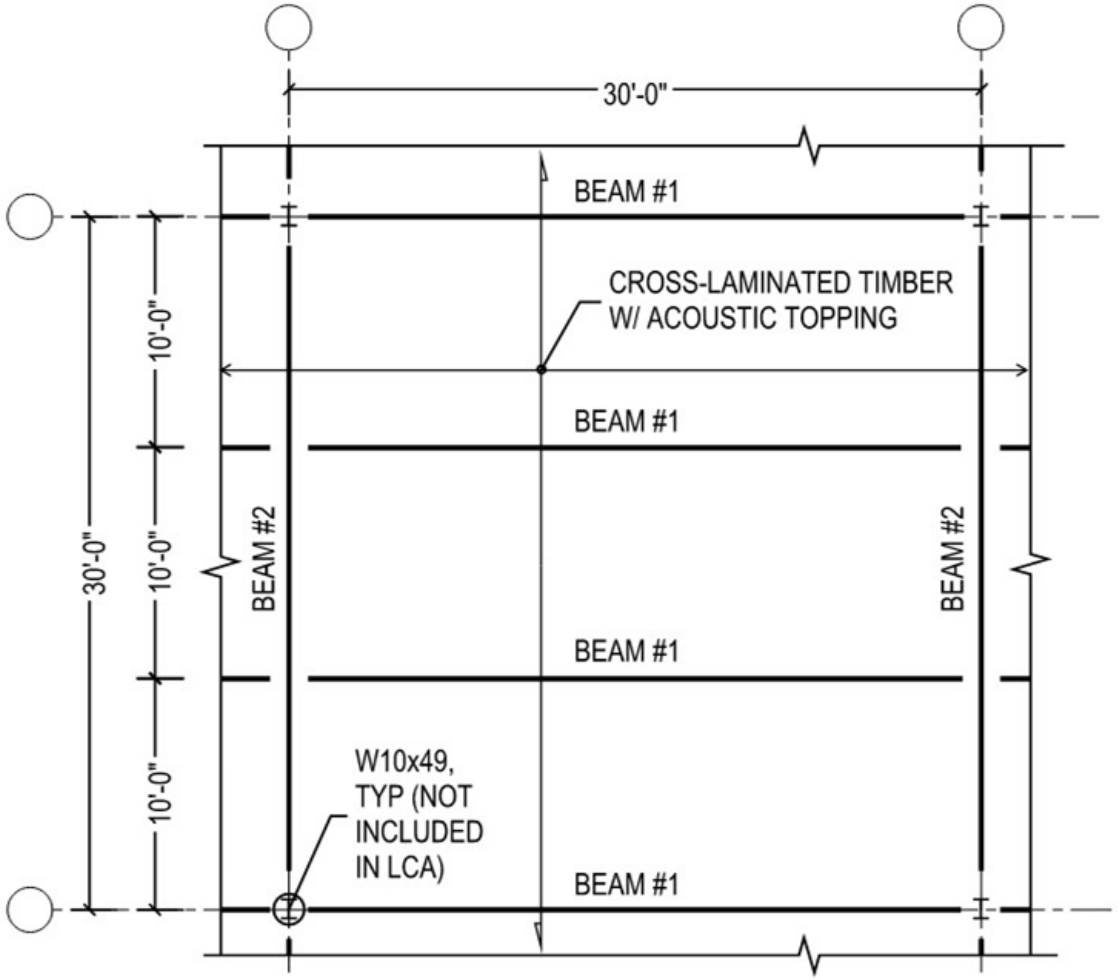
# MASS TIMBER POST-AND-BEAM OFFICE ECID



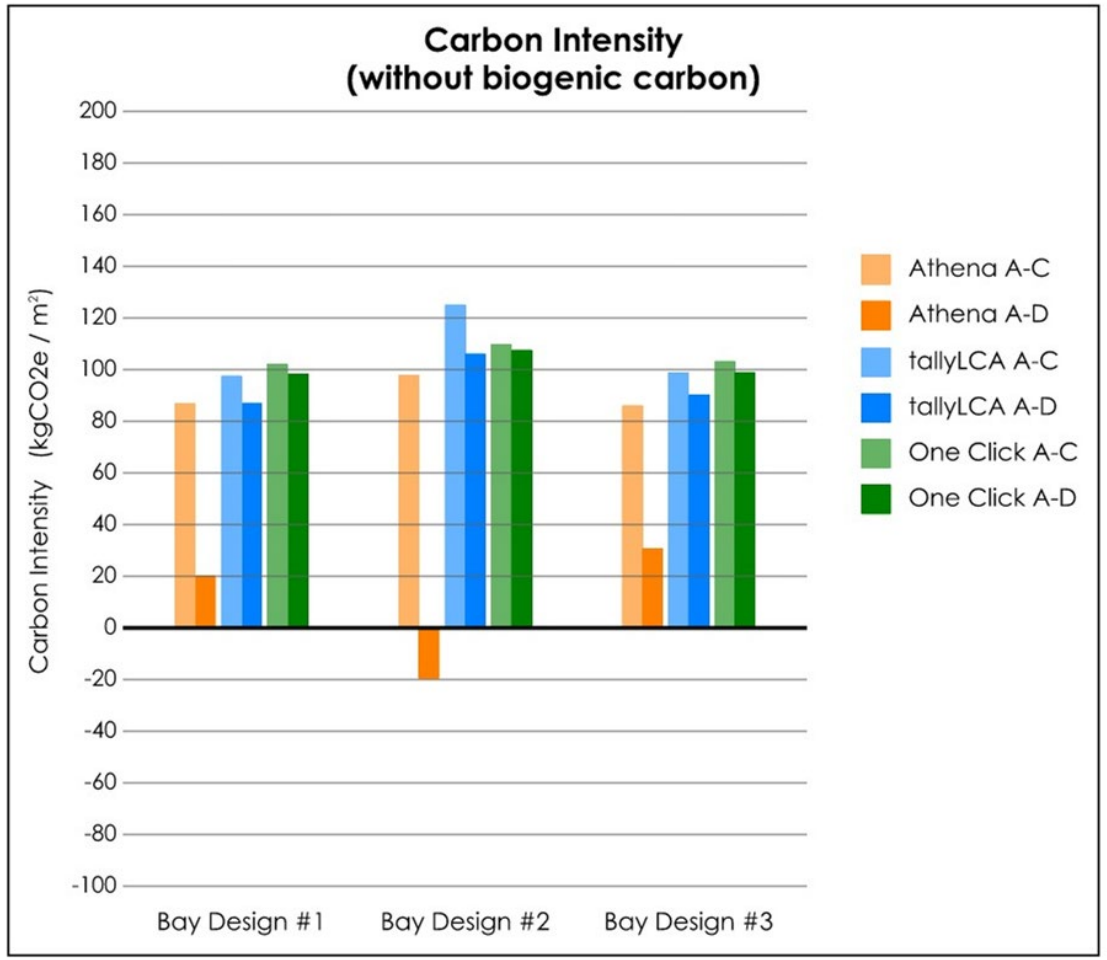

18'x30' MASS TIMBER
POST-AND-BEAM OFFICE BAY



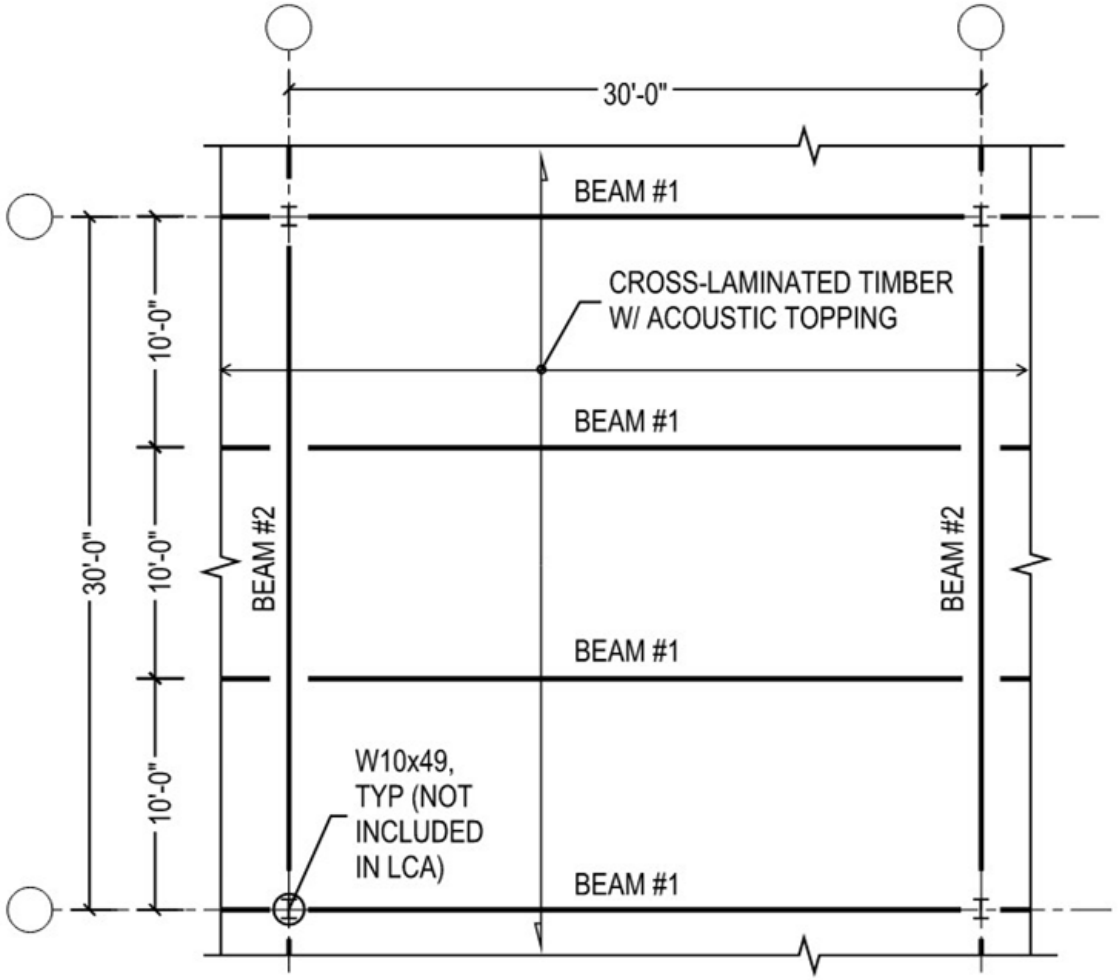
# HYBRID MASS TIMBER / STEEL OFFICE ECID



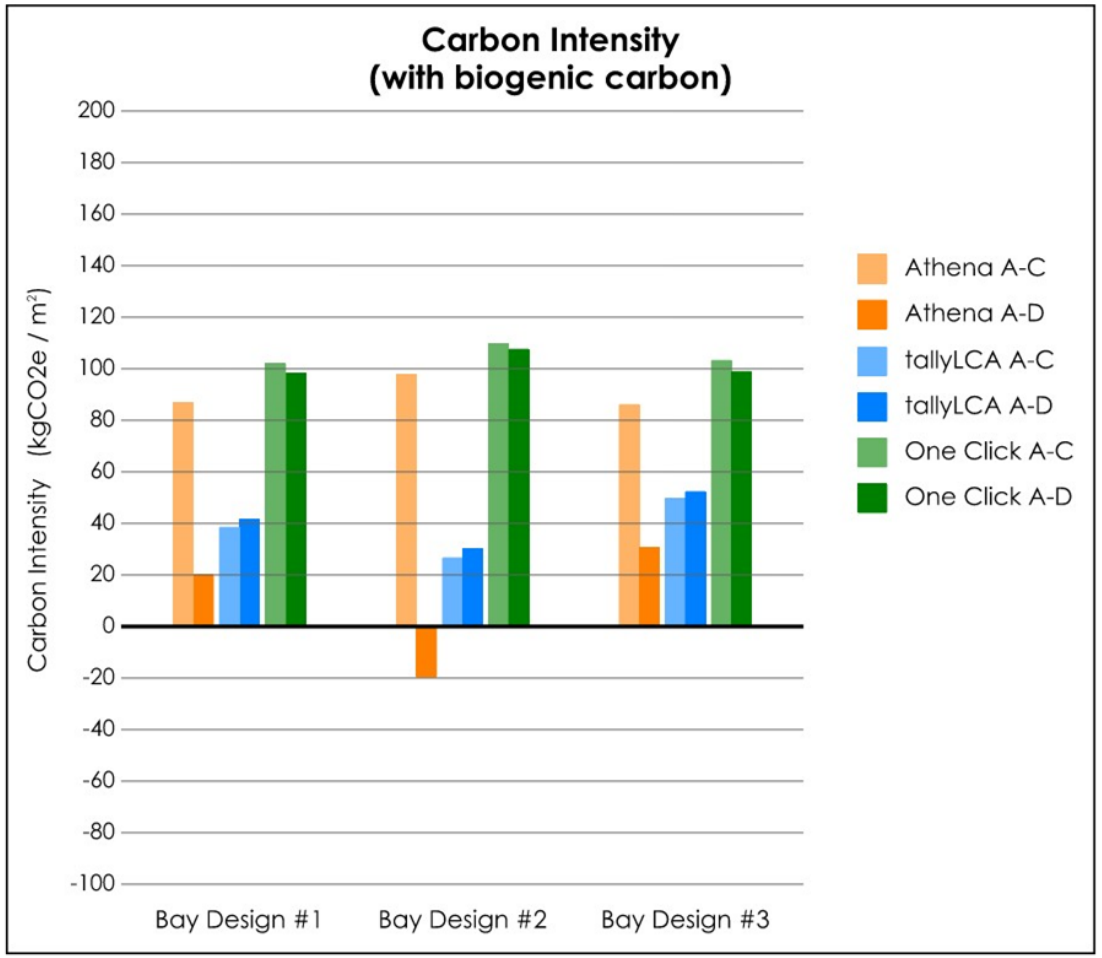

30'x30' HYBRID MASS TIMBER / STEEL OFFICE BAY



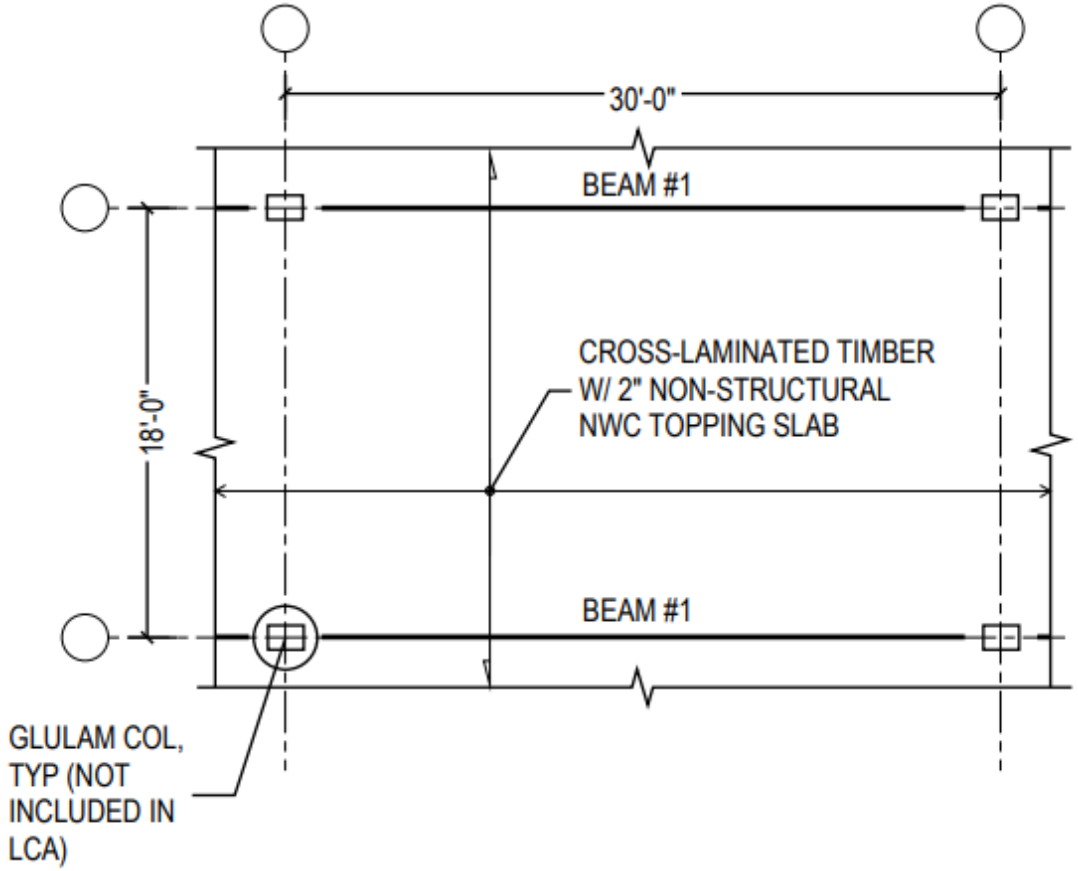
# HYBRID MASS TIMBER / STEEL OFFICE ECID



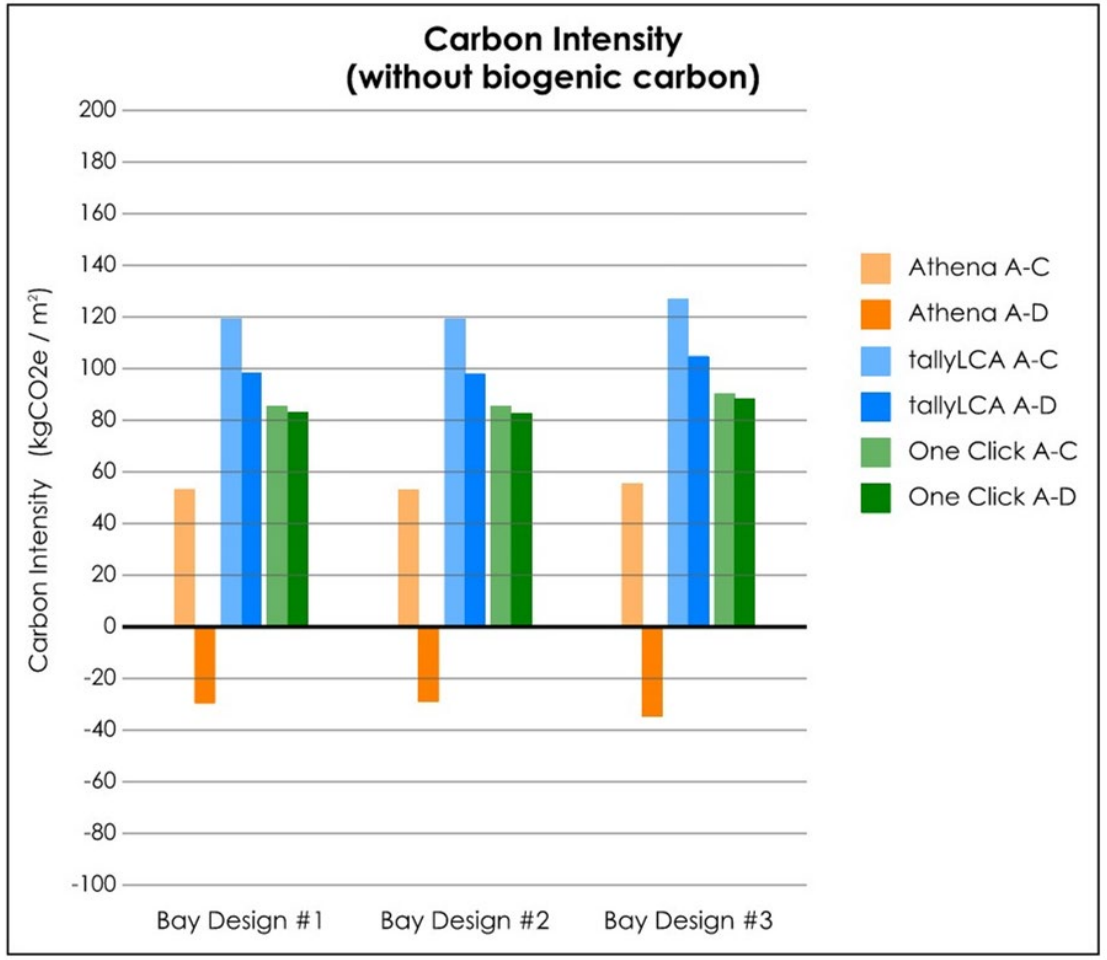

30'x30' HYBRID MASS TIMBER / STEEL OFFICE BAY



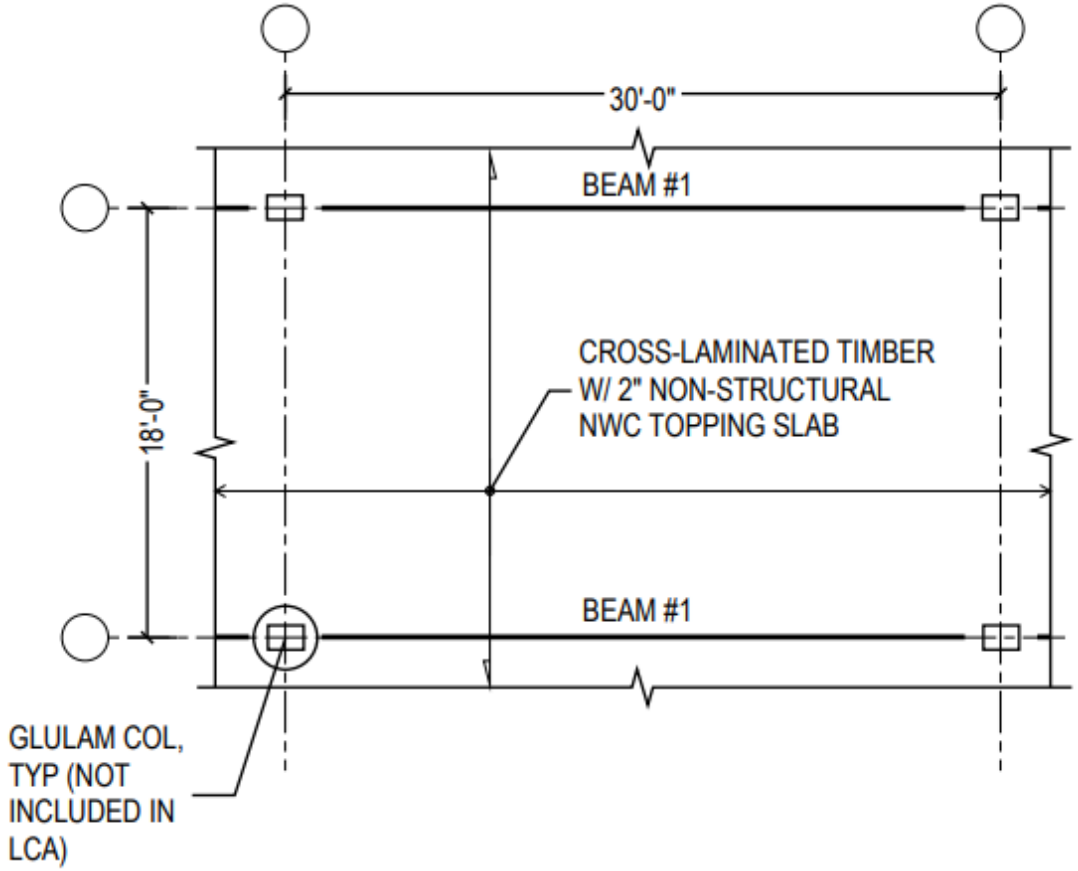
# MASS TIMBER POST-AND-BEAM OFFICE ECID



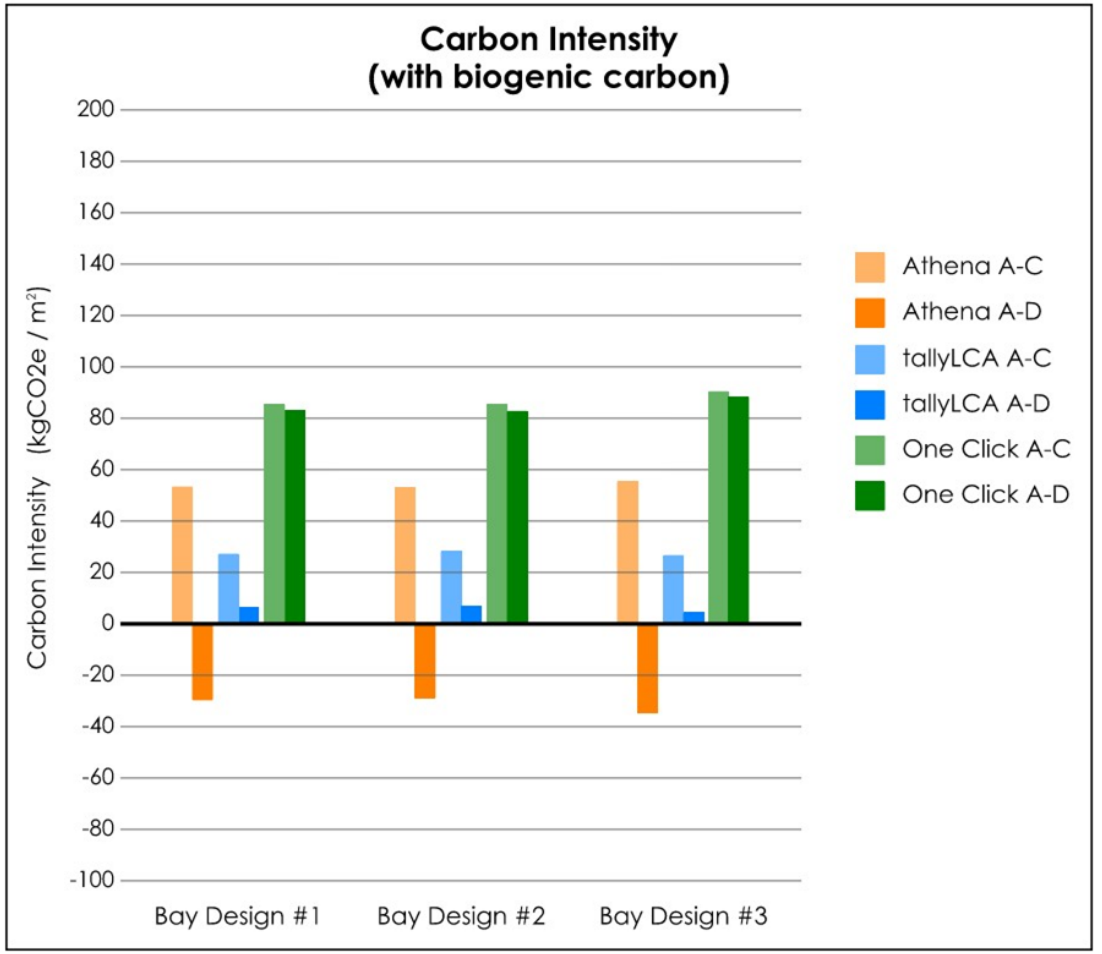

18'x30' MASS TIMBER
POST-AND-BEAM OFFICE BAY



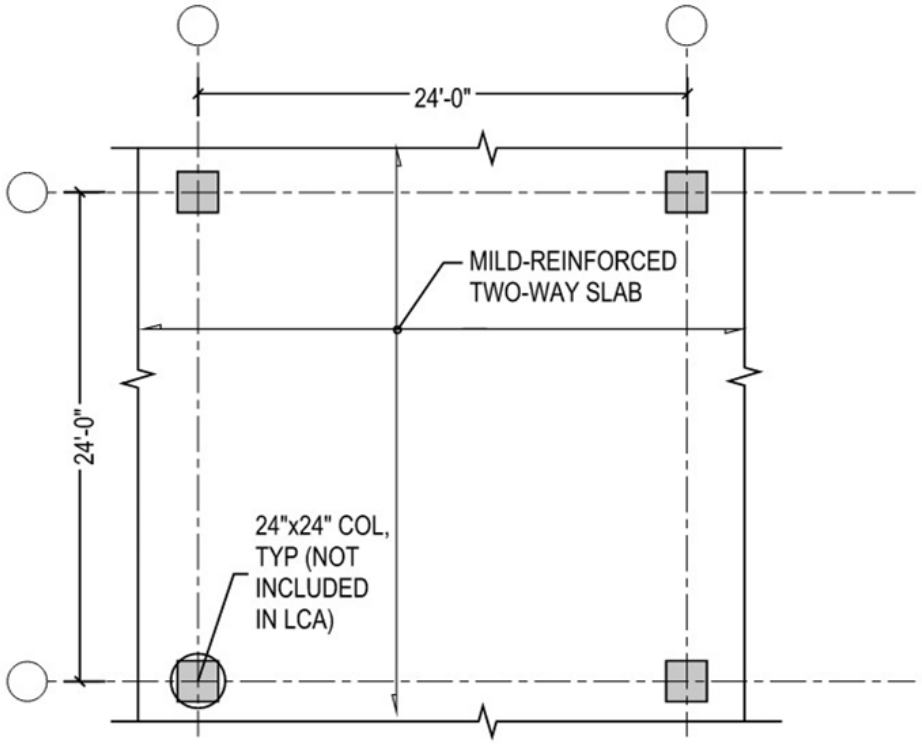
# MASS TIMBER POST-AND-BEAM OFFICE ECID



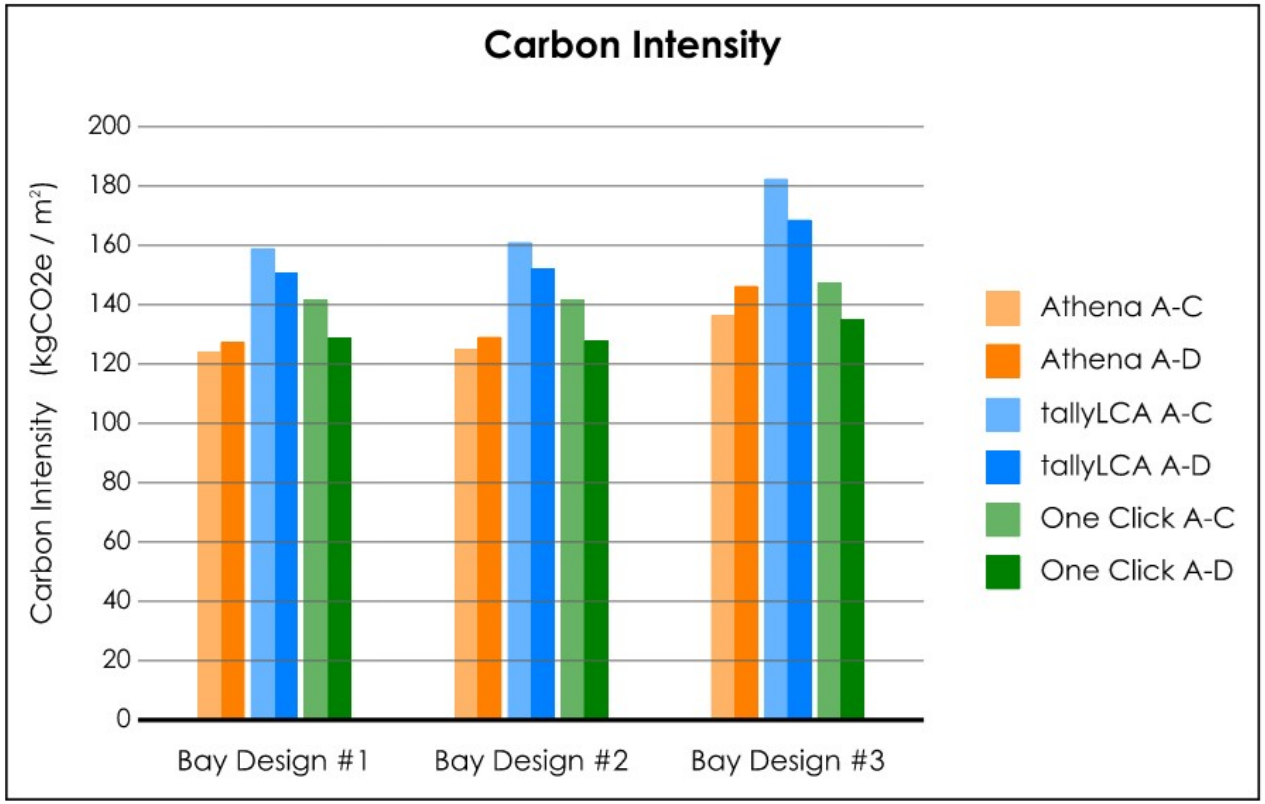

18'x30' MASS TIMBER
POST-AND-BEAM OFFICE BAY



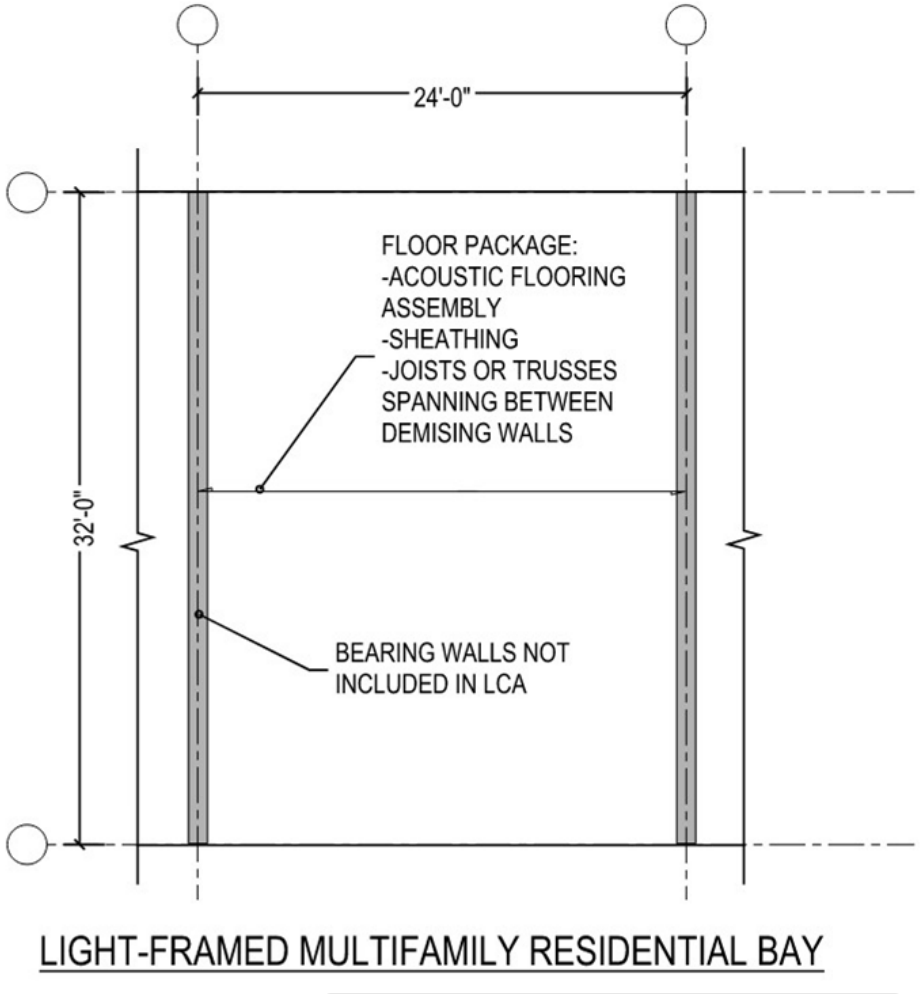
# MILD-REINFORCED CONCRETE FLAT PLATE RESIDENTIAL ECID



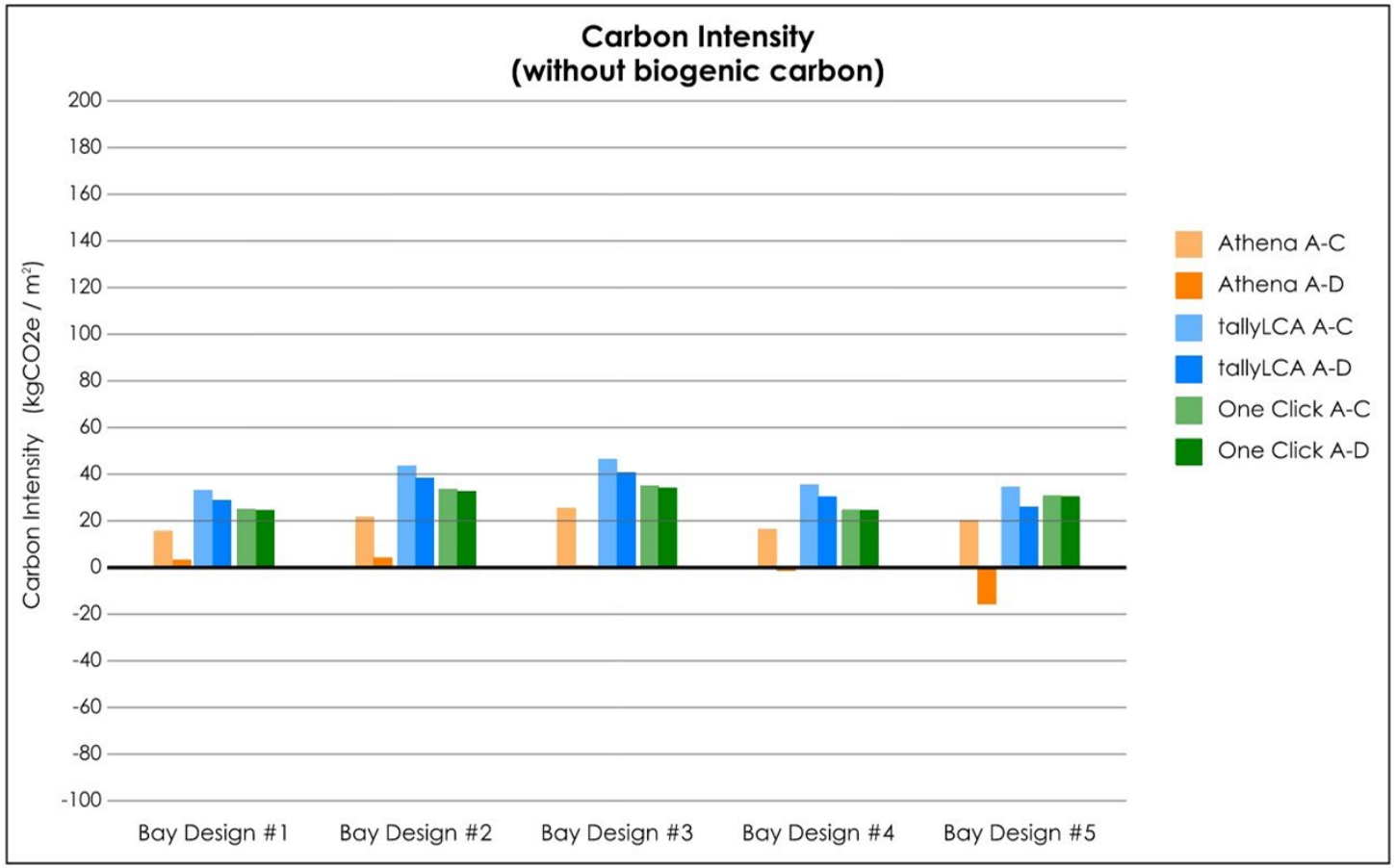

24'x24' MILD-REINFORCED CONCRETE FLAT PLATE RESIDENTIAL BAY



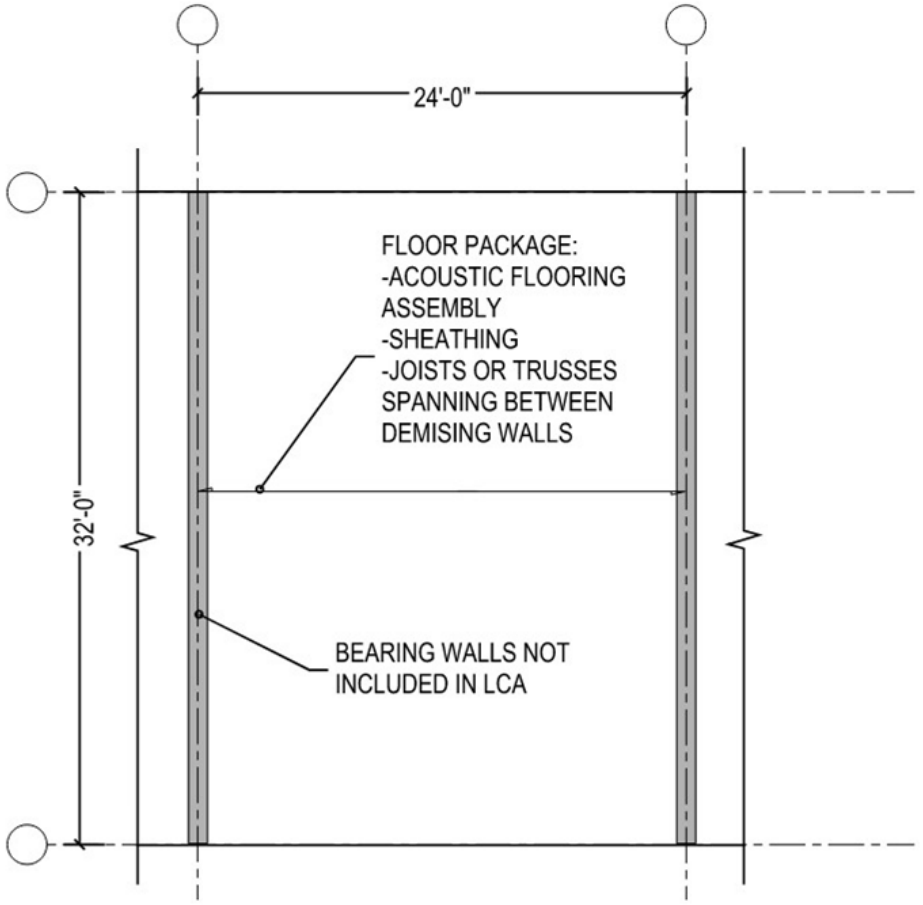
# LIGHT-FRAMED RESIDENTIAL ECID



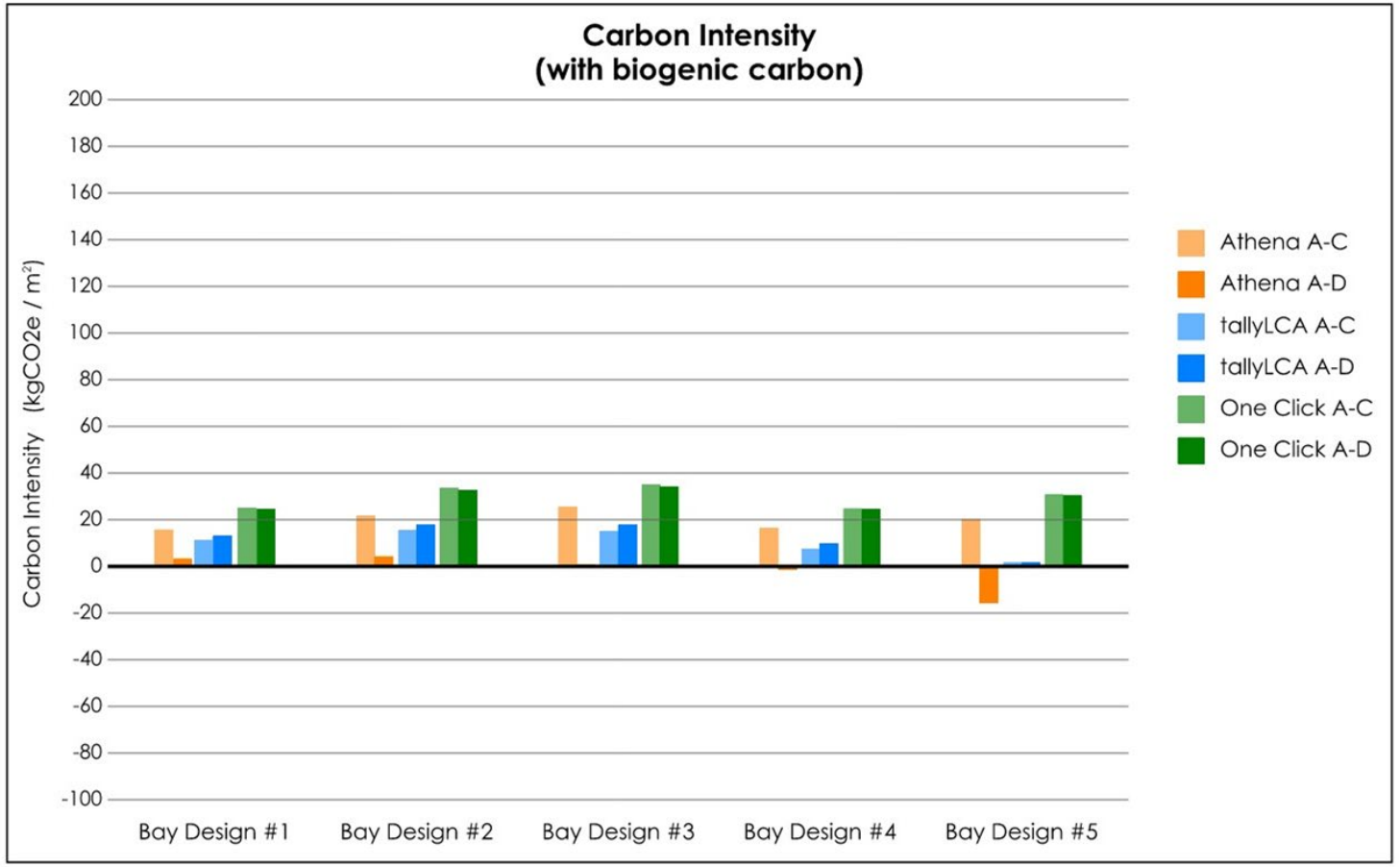

LIGHT-FRAMED MULTIFAMILY RESIDENTIAL BAY



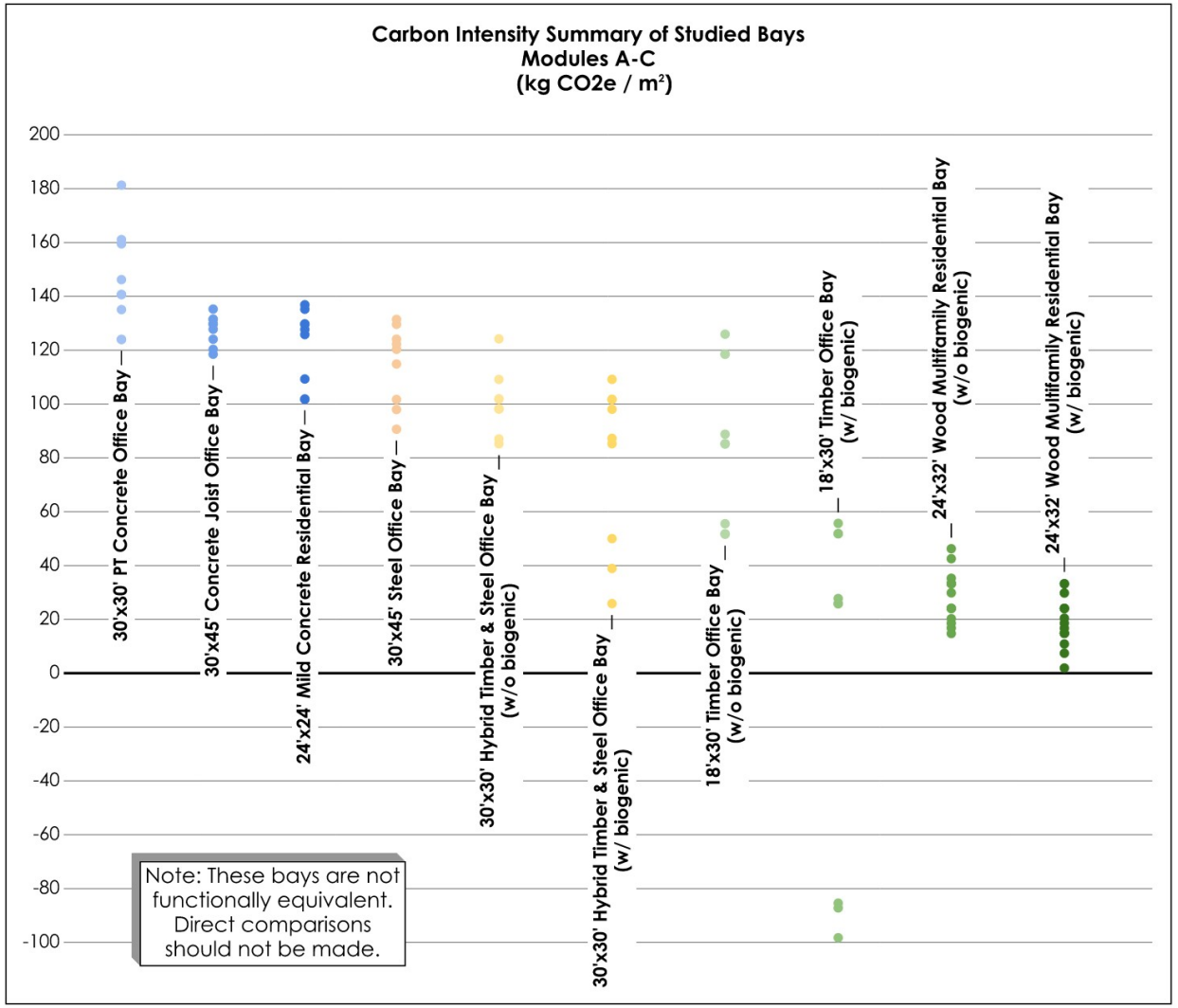
# LIGHT-FRAMED RESIDENTIAL ECID



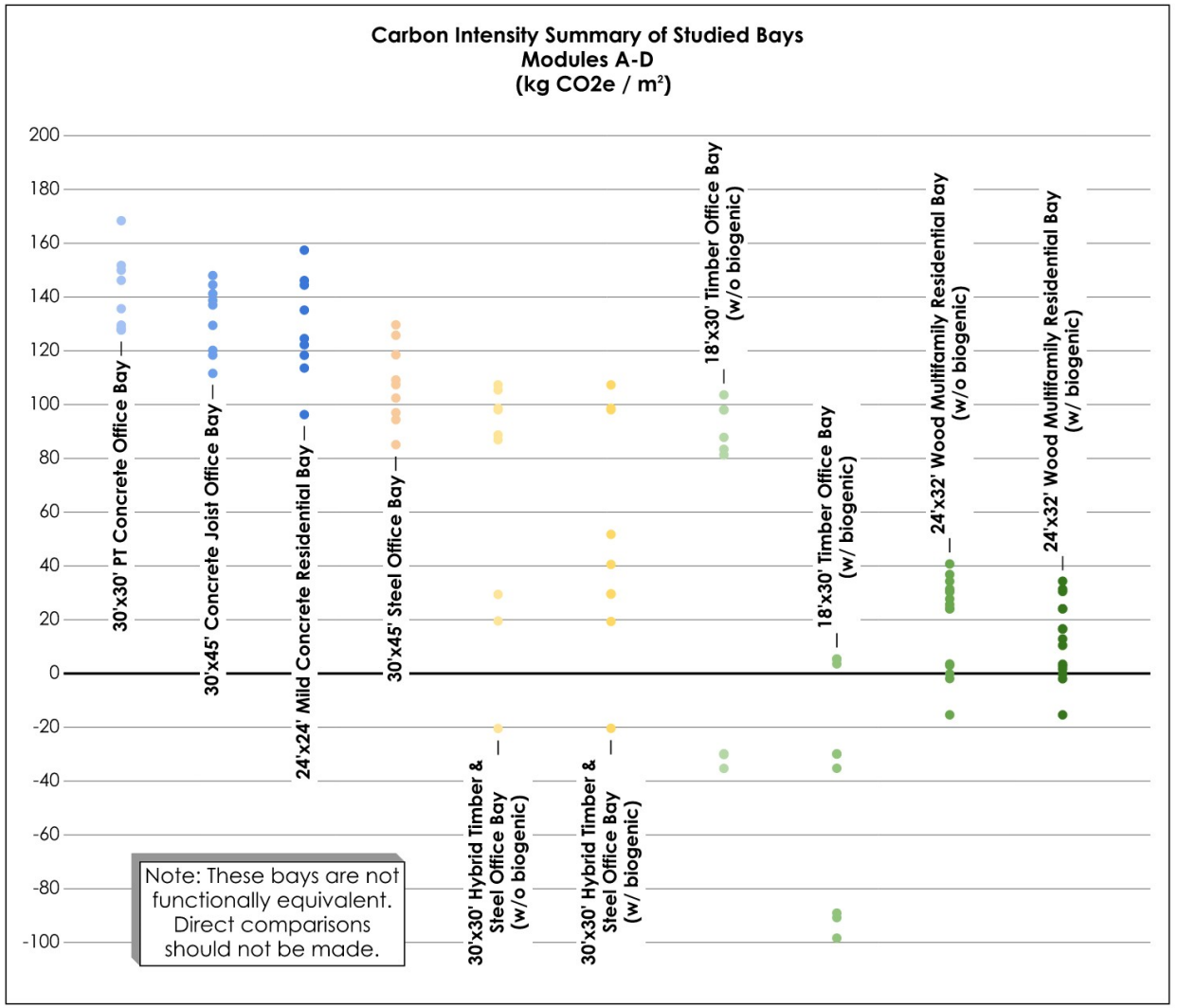

LIGHT-FRAMED MULTIFAMILY RESIDENTIAL BAY



# EMBODIED CARBON INTENSITY DIAGRAM SUMMARY



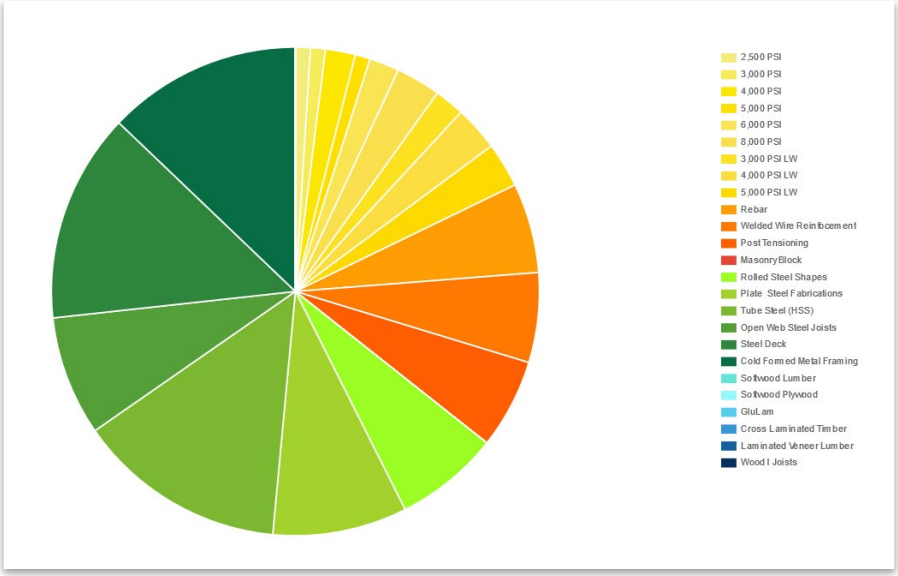
# EMBODIED CARBON INTENSITY DIAGRAM SUMMARY



# ECOM TOOL

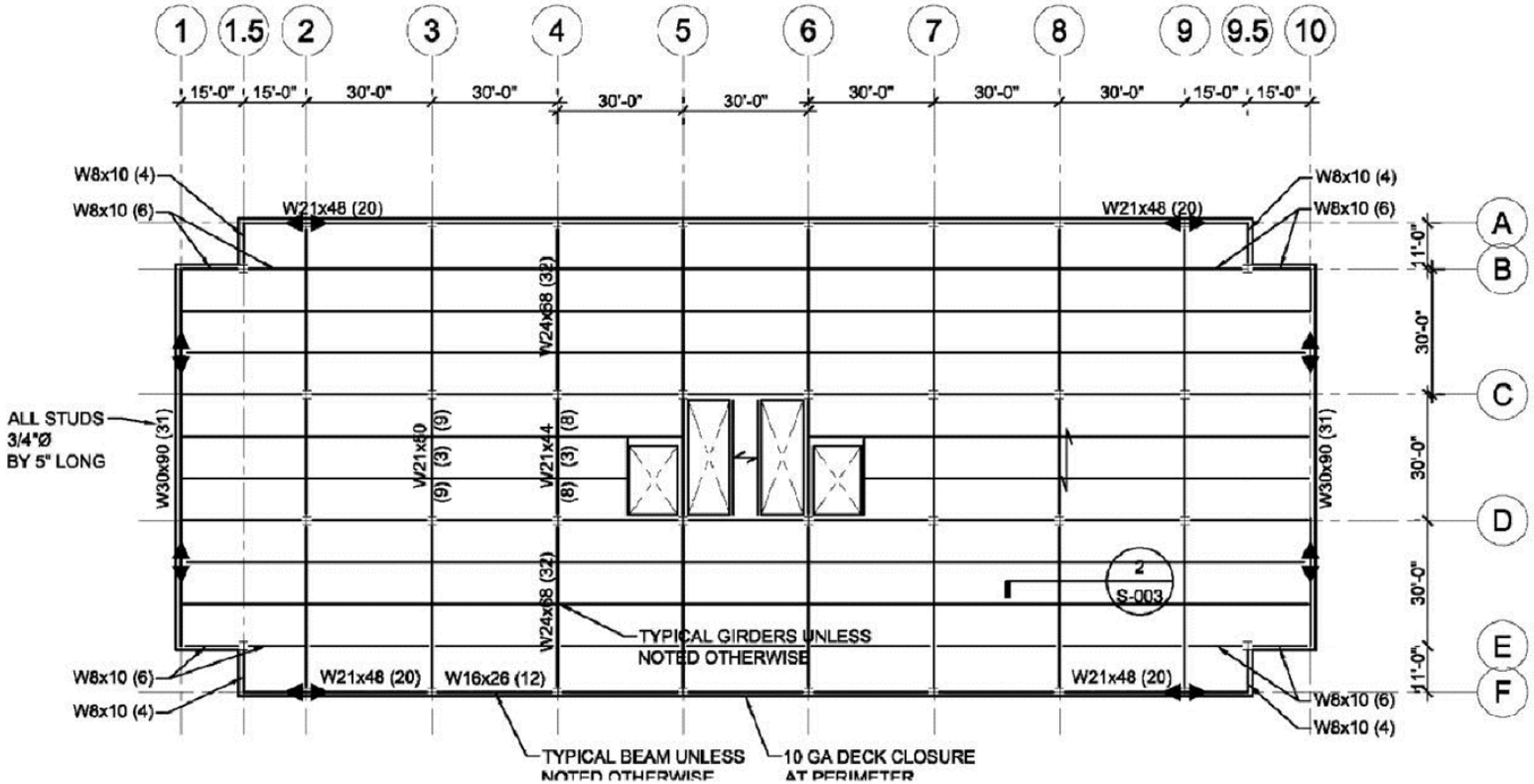
# ECOM TOOL

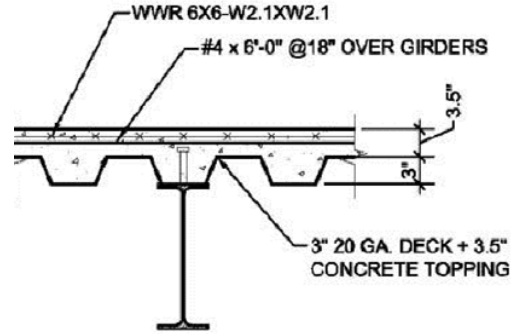
- **E**mbodied **C**arbon **O**rder of **M**agnitude Tool
- A simple product tool that calculates global warming potential
- Designers can identify hot spots




**https://se2050.org/ecom-tool/**

# EXAMPLE – FLOOR FRAMING




1 PLAN

1/32" = 1'-0"

WWR 6X6-W2.1XW2.1

# FLOOR PLATE MATERIAL QUANTITIES

| Item | Quantity |
|---|---|
| 3,500 psi Concrete | 455 Cubic Yards |
| Rebar | 1.25 Tons |
| Metal Deck | 34 Tons |
| Shear Studs | 1 Ton |
| Welded Wire Reinforcement | 4.25 Tons |
| Steel Shapes | 83 Tons |
| Deck Closure | 2.25 Tons |

# TEST YOUR KNOWLEDGE:

**Estimate the embodied carbon (Phases A1 - A3) in the floor framing (ca. 30,000 sf)**

- 3 Tons $CO_2e$
- 30 Tons $CO_2e$
- 300 Tons $CO_2e$
- 3,000 Tons $CO_2e$

# TEST YOUR KNOWLEDGE:

**Estimate the embodied carbon (Phases A1 - A3) in the floor framing**

- 3 Tons $CO_2e$
- 30 Tons $CO_2e$
- 300 Tons $CO_2e$
- 3,000 Tons $CO_2e$

# SE 2050 – ECOM - INPUT

| Material | Structural Component | Quantity | Unit | Total Impact (lb CO2e) | Total Impact (kg CO2e) | % of Total |
|---|---|---|---|---|---|---|
| Concrete | 2,500 PSI | 0 | Cubic Yards | 0 | 0 | 0.0% |
| | 3,000 PSI | 455 | Cubic Yards | 227,903.95 | 103,376.55 | 37.8% |
| | 4,000 PSI | Input quantity here | Cubic Yards | | | 0.0% |
| | 5,000 PSI | Input quantity here | Cubic Yards | | | 0.0% |
| | 6,000 PSI | Input quantity here | Cubic Yards | | | 0.0% |
| | 8,000 PSI | Input quantity here | Cubic Yards | | | 0.0% |
| | 3,000 PSI LW | Input quantity here | Cubic Yards | | | 0.0% |
| | 4,000 PSI LW | Input quantity here | Cubic Yards | | | 0.0% |
| | 5,000 PSI LW | Input quantity here | Cubic Yards | | | 0.0% |
| Steel Reinforcement | Rebar | 1.21 | Tons | 2,369.18 | 1,074.65 | 0.4% |
| | Welded Wire Reinfocement | 4.25 | Tons | 8,321.5 | 3,774.61 | 1.4% |
| | Post Tensioning | Input quantity here | Tons | | | 0.0% |
| Masonry | Normal Weight Masonry Block | Input quantity here | Tons | | | 0.0% |
| | Light Weight Masonry Block | Input quantity here | Tons | | | 0.0% |
| | Masonry Grout | Input quantity here | Cubic Yards | | | 0.0% |
| | Mortar | Input quantity here | Cubic Yards | | | 0.0% |
| Steel | Rolled Steel Shapes | 83 | Tons | 192,560 | 87,344.64 | 32.0% |
| | Plate Steel Fabrications | Input quantity here | Tons | | | 0.0% |
| | Tube Steel (HSS) | Input quantity here | Tons | | | 0.0% |
| | Open Web Steel Joists | Input quantity here | Tons | | | 0.0% |
| | Steel Deck | 34 | Tons | 161,160 | 73,101.7 | 26.7% |
| | Cold Formed Metal Framing | 2.25 | Tons | 10,260 | 4,653.91 | 1.7% |
| Timber | Softwood Lumber | Input quantity here | Cubic Feet | | | 0.0% |
| | Softwood Plywood | Input quantity here | Cubic Feet | | | 0.0% |
| | GluLam | Input quantity here | Cubic Feet | | | 0.0% |
| | Cross Laminated Timber | Input quantity here | Cubic Feet | | | 0.0% |
| | Laminated Veneer Lumber | Input quantity here | Cubic Feet | | | 0.0% |
| | Wood I Joists | Input quantity here | LBS | | | 0.0% |

| Embodied Carbon Area | |
|---|---|
| Total Area ($ft^2$) | 29,000 |
| Total Area ($m^2$) | 2,694.1 |

| | | | |
|---|---|---|---|
| Steel Reinforcement | Rebar | 1.21 | Tons |
| | Welded Wire Reinfocement | 4.25 | Tons |
| | Post Tensioning | Input quantity here | Tons |

# TEST YOUR KNOWLEDGE:

**Which assemblies are responsible for at least 25% of the embodied carbon in floor framing? (Choose all that apply)**

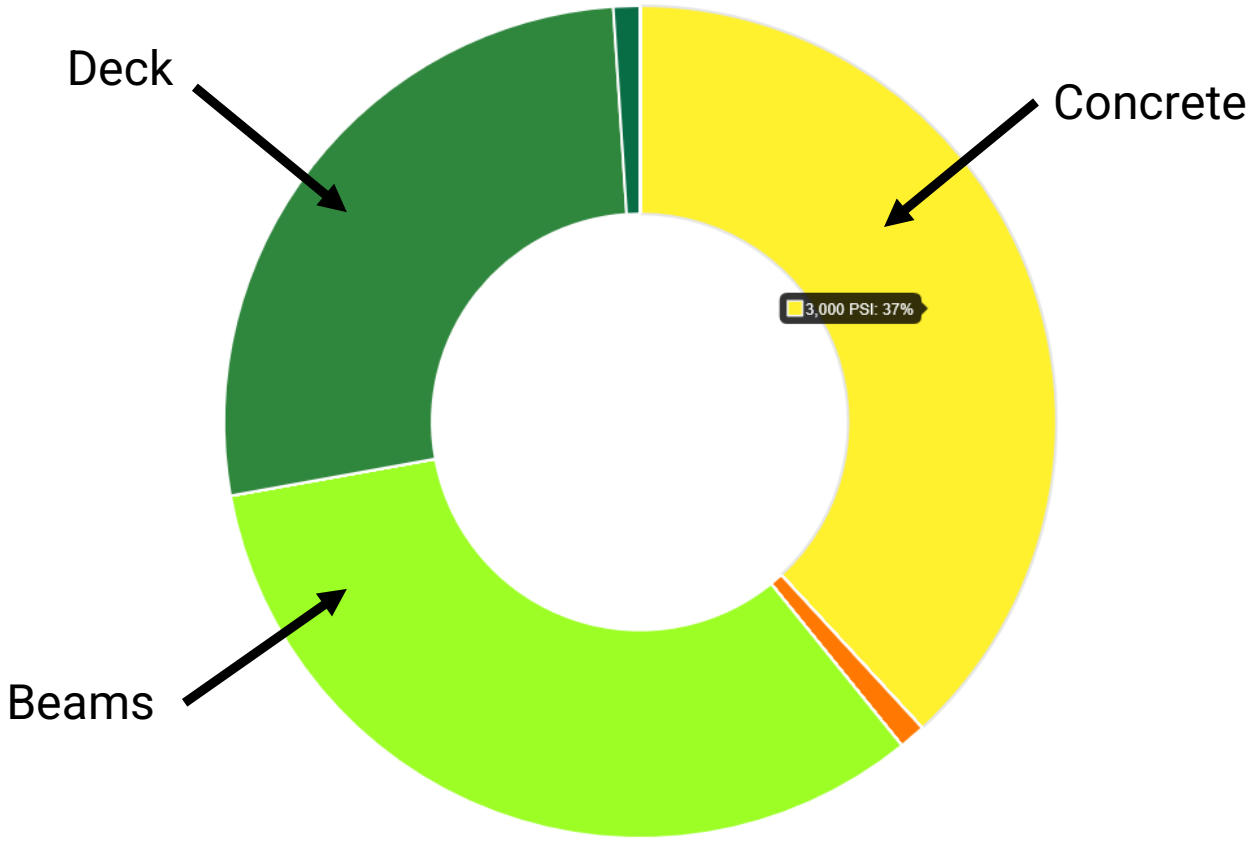
- ○ Steel Beams
- ○ Steel Deck
- ○ Rebar
- ○ Concrete

# TEST YOUR KNOWLEDGE:

**Which assemblies are responsible for at least 25% of the embodied carbon in floor framing? (Choose all that apply)**

- Steel Beams
- Steel Deck
- Rebar
- Concrete

# SE 2050 – ECOM OUTPUT




- 2,500 PSI
- 3,000 PSI
- 4,000 PSI
- 5,000 PSI
- 6,000 PSI
- 8,000 PSI
- 3,000 PSI LW
- 4,000 PSI LW
- 5,000 PSI LW
- Rebar
- Welded Wire Reinfocement
- Post Tensioning
- Normal Weight Masonry Block
- Light Weight Masonry Block
- Masonry Grout
- Mortar
- Rolled Steel Shapes
- Plate Steel Fabrications
- Tube Steel (HSS)
- Open Web Steel Joists
- Steel Deck
- Cold Formed Metal Framing
- Softwood Lumber
- Softwood Plywood
- GluLam
- Cross Laminated Timber
- Laminated Veneer Lumber
- Wood I Joists

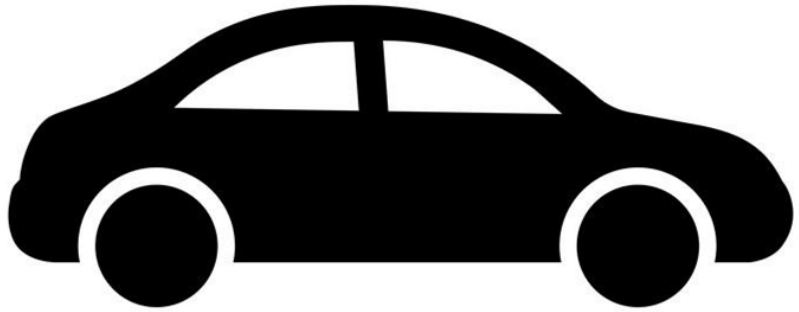
| Embodied Carbon Totals | |
|---|---|
| Total Impact (lb $CO_2e$) | 602,573 |
| Total Impact (kg $CO_2e$) | 273,322 |

| Embodied Carbon Intensities | |
|---|---|
| Intensity (lb $CO_2e$/ $ft^2$) | 20.78 |
| Intensity (kg $CO_2e$/ $m^2$) | 101.45 |

# TEST YOUR KNOWLEDGE - CONTEXT

**The embodied carbon in the floor is roughly equivalent to driving….**

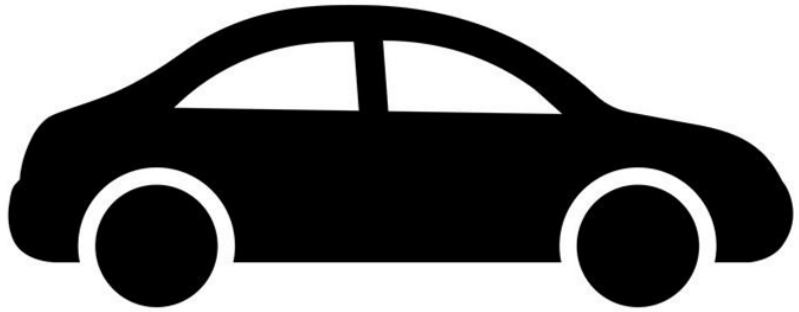
- >500 Miles?
- >5,000 Miles?
- >50,000 Miles?
- >500,000 Miles?



# TEST YOUR KNOWLEDGE - CONTEXT

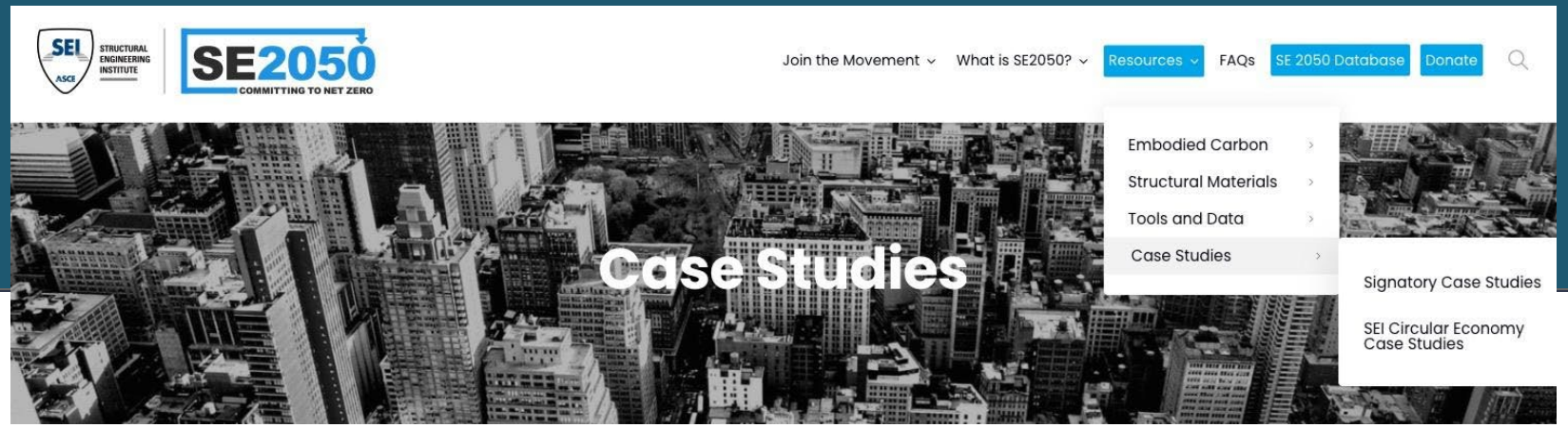
**The embodied carbon in the floor is roughly equivalent to driving….**

- >500 Miles?
- >5,000 Miles?
- >50,000 Miles?
- >500,000 Miles?



# CASE STUDIES

# CASE STUDIES




## Signatory Case Studies (coming soon)

## SEI Circular Economy Case Studies

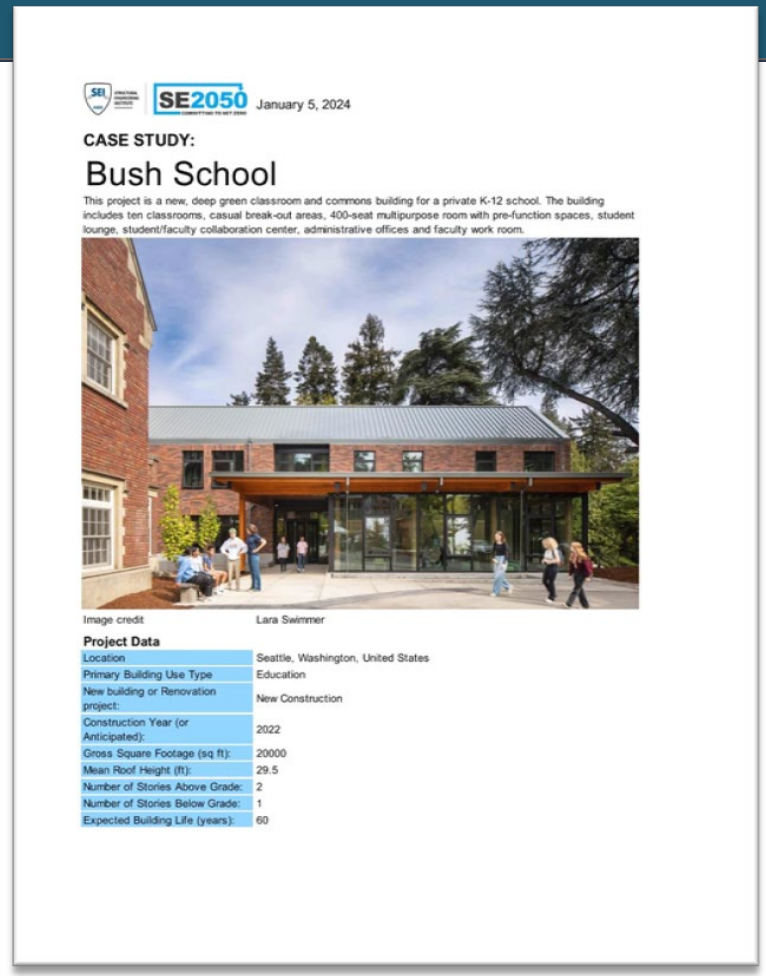
# SIGNATORY CASE STUDIES

The SE 2050 Resources Working Group is calling on all signatories to contribute project case studies for publication on the SE 2050 website!

Firms are invited to contribute project-specific key findings, recommendations and lessons learned as related to implemented embodied carbon reduction strategies.

Projects submitted could be SE 2050 database contributions but do not need to be.

Projects may be anonymous or identified.



SE2050 January 5, 2024

CASE STUDY:

Bush School

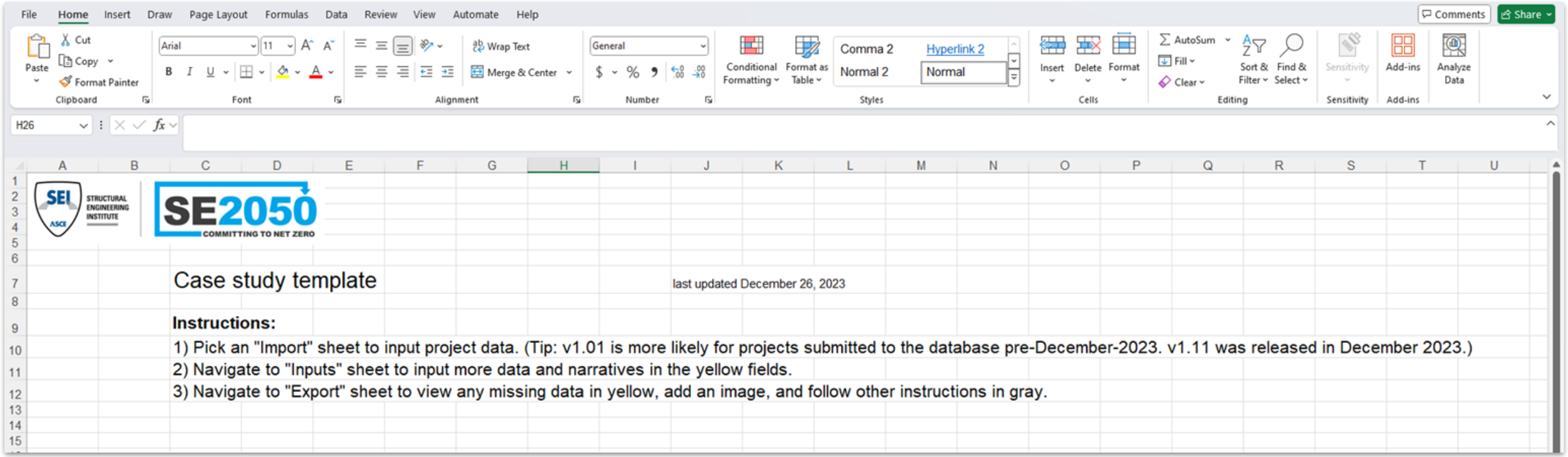
This project is a new, deep green classroom and commons building for a private K-12 school. The building includes ten classrooms, casual break-out areas, 400-seat multipurpose room with pre-function spaces, student lounge, student/faculty collaboration center, administrative offices and faculty work room.

Image credit Lara Swimmer

**Project Data**

| | |
|---|---|
| Location | Seattle, Washington, United States |
| Primary Building Use Type | Education |
| New building or Renovation project: | New Construction |
| Construction Year (or Anticipated): | 2022 |
| Gross Square Footage (sq ft): | 20000 |
| Mean Roof Height (ft): | 29.5 |
| Number of Stories Above Grade: | 2 |
| Number of Stories Below Grade: | 1 |
| Expected Building Life (years): | 60 |

# SIGNATORY CASE STUDIES



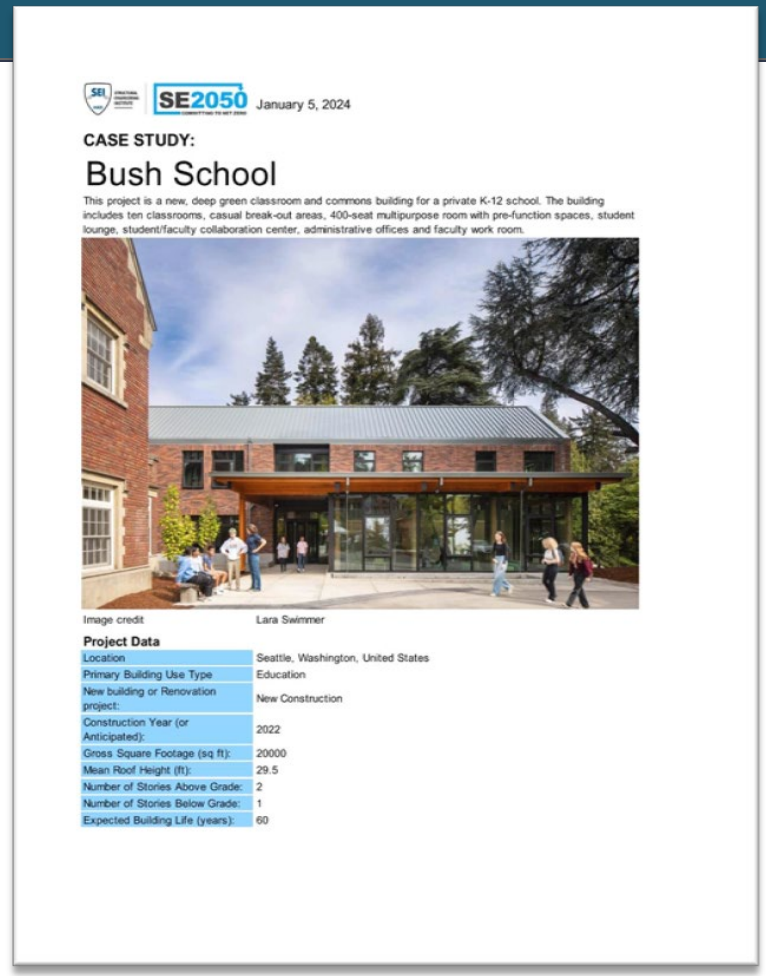

Our provided template makes it easy to prepare a case study submission, especially if you have used the Database Input Spreadsheet to submit the project.

# SIGNATORY CASE STUDIES

Motivations for this effort include:

- **Share lessons learned**, successes & challenges
- **Contribute knowledge** in reducing emissions at an industry level
    - This type of knowledge-sharing was specifically requested by signatory firms
- **Uncover narratives** behind one anonymized data point in the database
- **Demonstrate leadership** to clients and future talent

We hope to hear from you!



SE2050 January 5, 2024

CASE STUDY:

Bush School

This project is a new, deep green classroom and commons building for a private K-12 school. The building includes ten classrooms, casual break-out areas, 400-seat multipurpose room with pre-function spaces, student lounge, student/faculty collaboration center, administrative offices and faculty work room.

Image credit Lara Swimmer

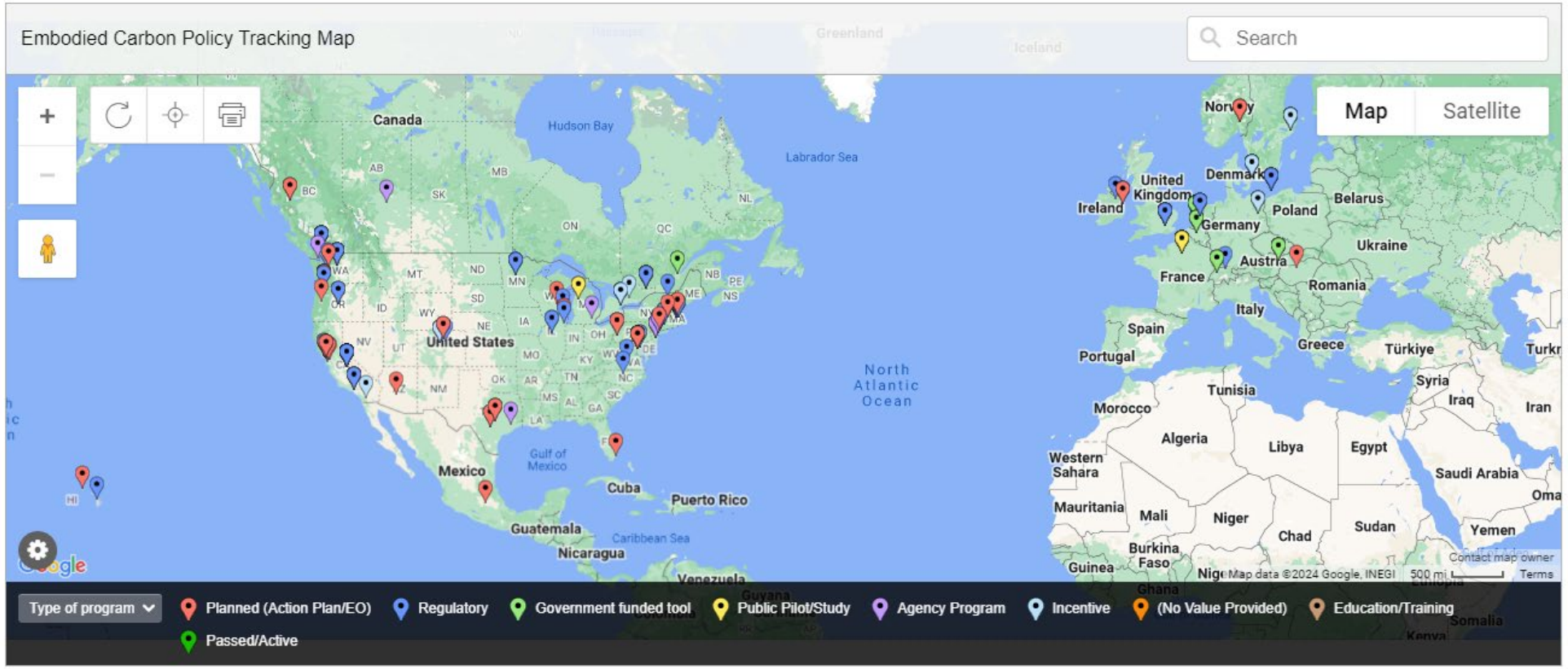
**Project Data**

| | |
|---|---|
| Location | Seattle, Washington, United States |
| Primary Building Use Type | Education |
| New building or Renovation project: | New Construction |
| Construction Year (or Anticipated): | 2022 |
| Gross Square Footage (sq ft): | 20000 |
| Mean Roof Height (ft): | 29.5 |
| Number of Stories Above Grade: | 2 |
| Number of Stories Below Grade: | 1 |
| Expected Building Life (years): | 60 |

# EMBODIED CARBON POLICIES

# EMBODIED CARBON POLICIES

- Carbon Leadership Forum's Policy Map
- SE 2050-NCSEA Policy Subgroup



# EXTERNAL RESOURCES

# EXTERNAL RESOURCES

- Reference Materials:
  - “Sustainability Guidelines for the Structural Engineer”
  - “Whole Building Life Cycle Assessment – Reference Building Structure and Strategies”
  - “Structural Materials and Global Climate”
  - “Achieving Net Zero Embodied Carbon in Structural Materials by 2050”
- Web Resources:
  - www.SE2050.org
  - www.seisustainability.org
  - https://carbonleadershipforum.org/