



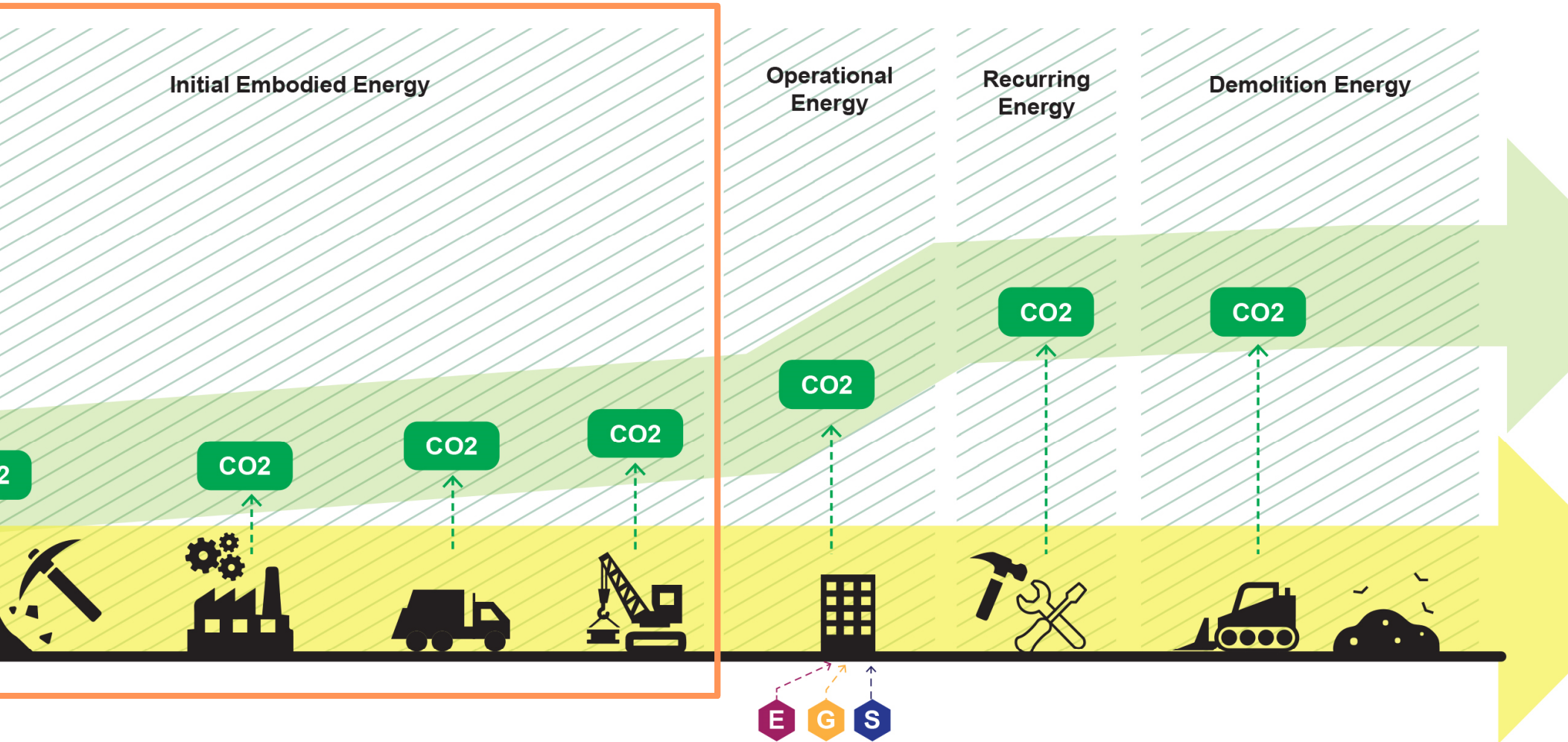
New Priorities – Embodied Carbon in Concrete Construction

Presenter: Michael E. Cropp

ACI Strategic Development Council Forum

February 13

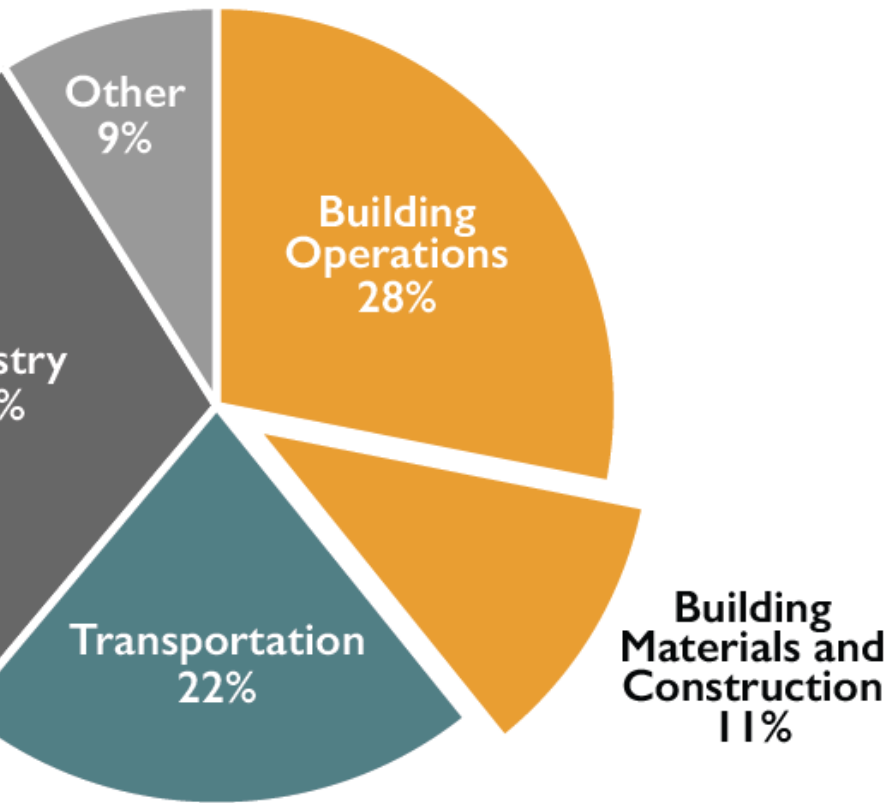
What is Embodied Carbon?



Cradle to Grave Building Life Cycle

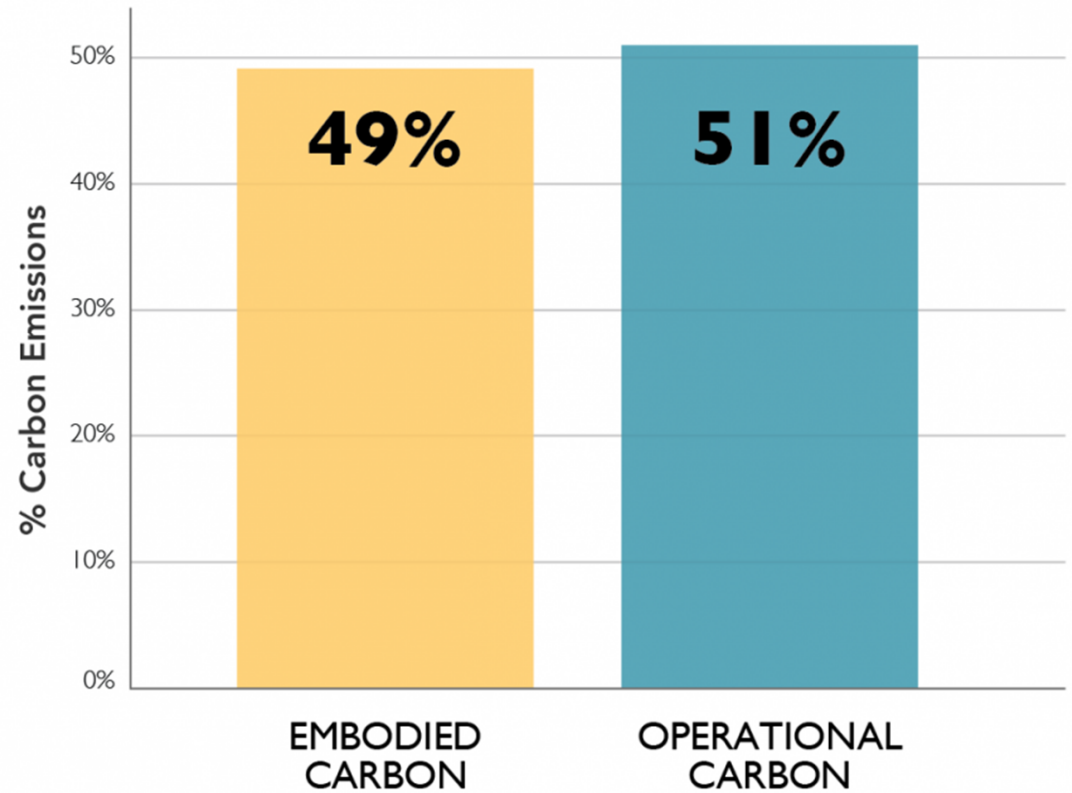
in the Built Environment

Total CO₂ Emissions by Sector



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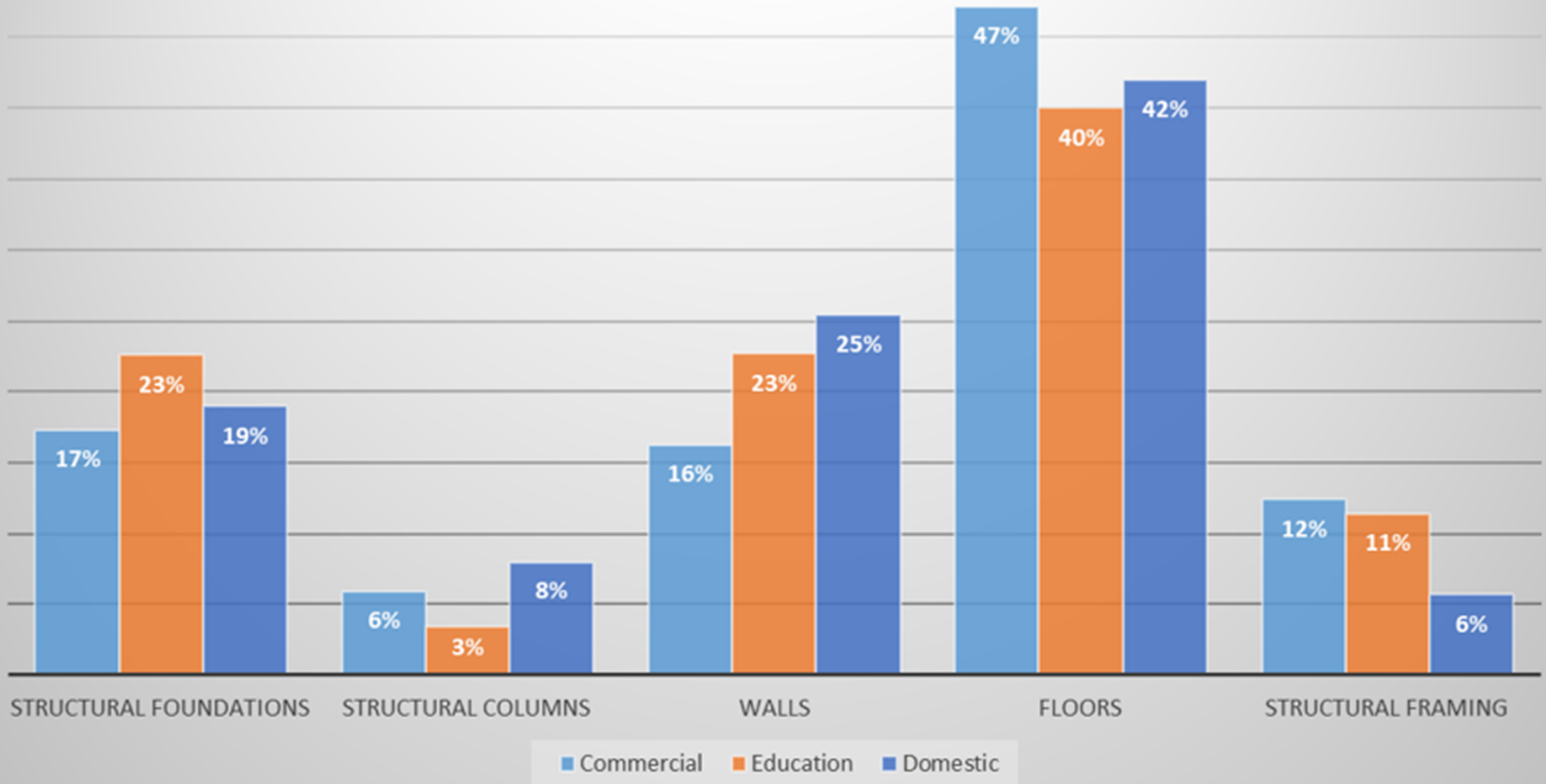
Total Carbon Emissions of Global New Construction from 2020-2050 Business as Usual Projection



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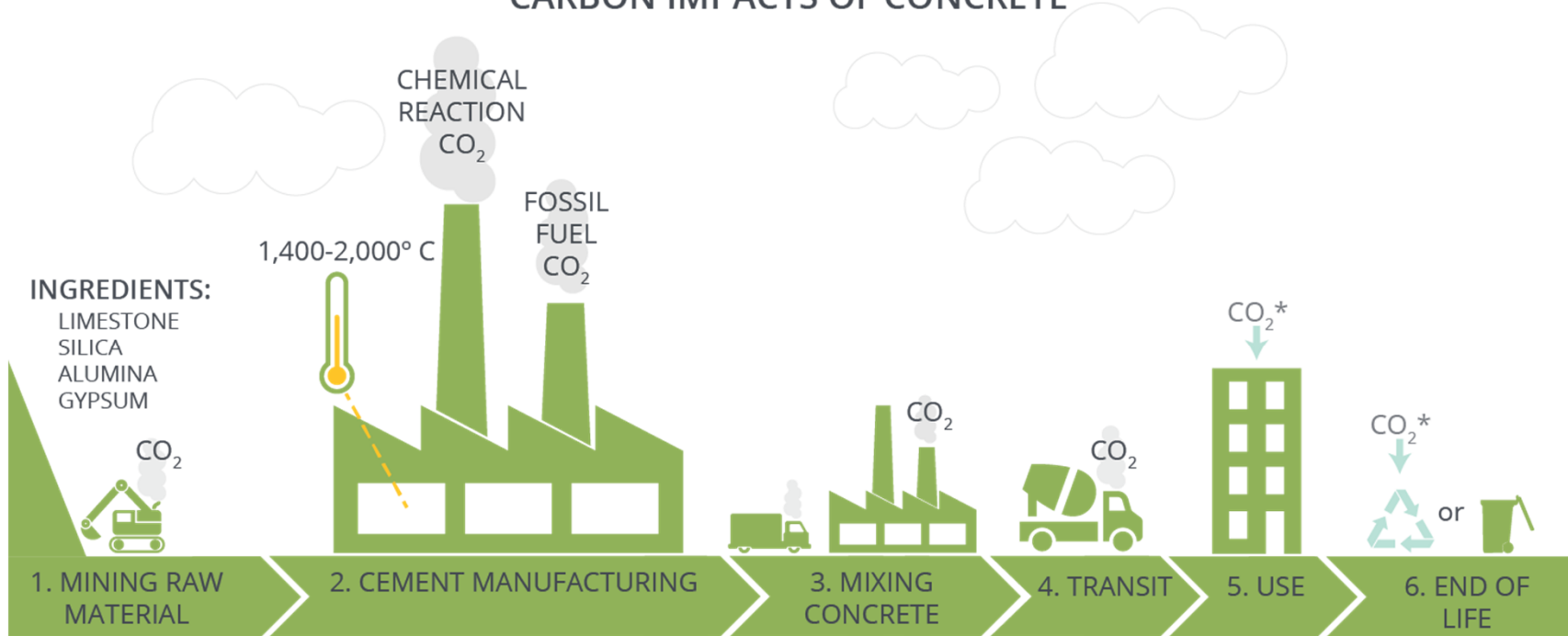
in Building Structure

Where is the Embodied Carbon?

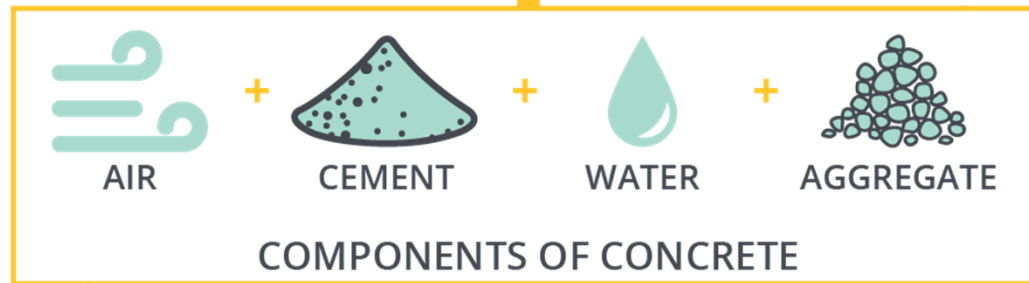


in Concrete Construction

CARBON IMPACTS OF CONCRETE



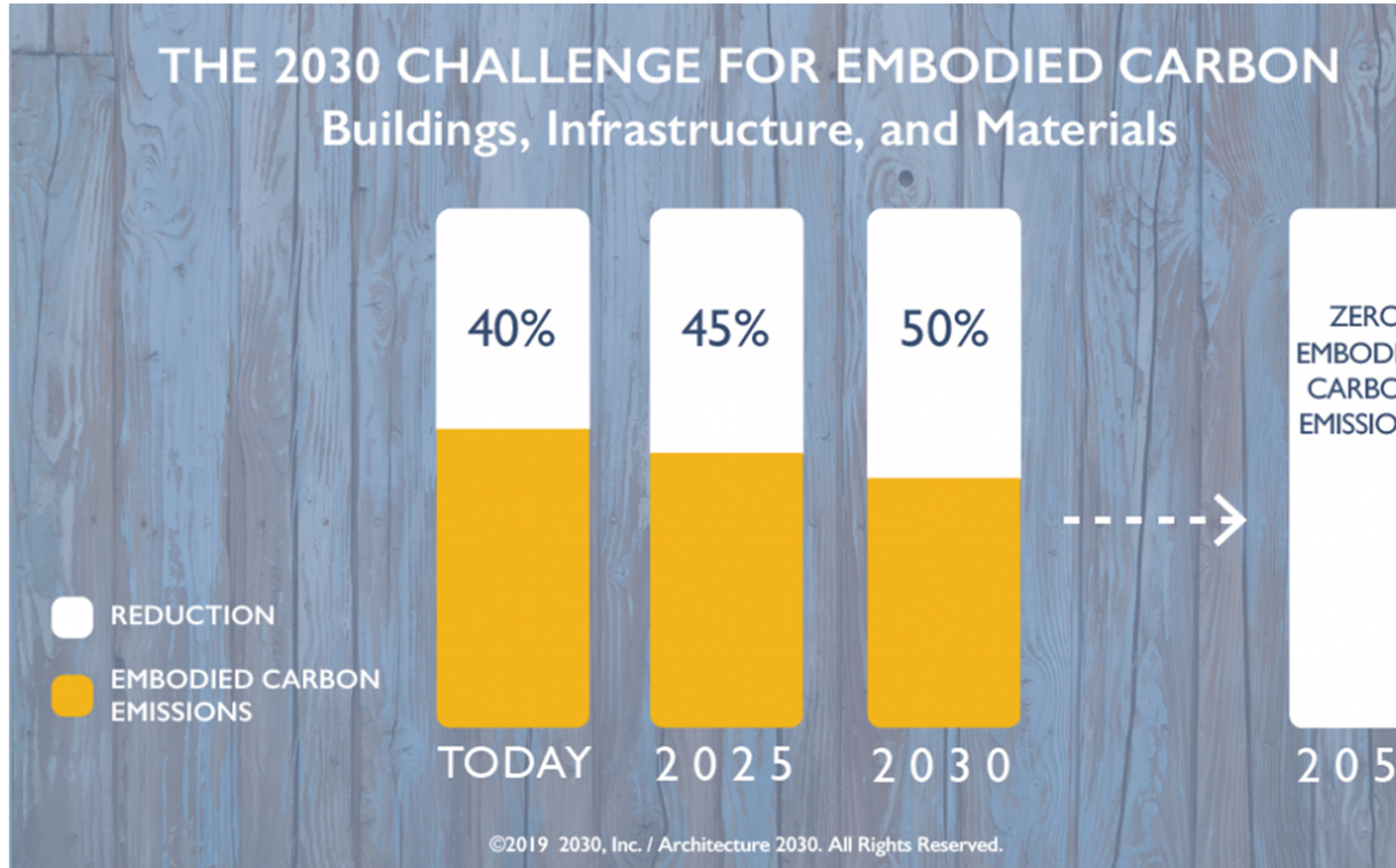
END OF LIFE:
Concrete can be ground up at the end of its useful life to make aggregate for new concrete.
* If exposed to air, concrete will absorb some CO₂



Industry Response



4 Building Lifecycle Reduction



Recent shift in owner thinking

What defines a successful project?

On Budget

On Schedule

Achieves the Design Vision

Achieves Sustainability Targets

(Embodied + Operational Carbon)



Highway to EC Reductions

Data collection and assessment
Product Declarations (EPDs)
Resilience
Material choice (best suited for the job)
Architecture
Material efficiency (design)
Material optimization (concrete mix)
Tracking and evaluation



Courtesy: Thornton Tomasetti

Material Collection and Assessment

Compare Buildings / Search Results

Classify to compare with similar buildings

Geocoding to get local products and transport

Confidentiality, Sharing, and Publishing

Visualize Structural

Building Use: Office

Approximate Construction Start Date: 10/11/2018

WA 98052, United States

GWP SAVINGS OPPORTUNITIES FOR TOWER #2, CALIFORNIA, 2021

Tower #2, California, 2021

RebarSteel: 40 ksi

Other Struct

Foundations

Shell

Conservative EC Estimate

33%

Achievable EC Target

Net Zero Embodied Carbon

Substructure: Conservative: 20.6k t CO2e, Achievable: 14.7k t CO2e, 29% Savings

Basement Walls

Columns

Floors

Composite Decks

Substructure

Braced Frames

Shallow Foundations

Trusses

Misc Walls

Other Struct

Misc

Concrete: 8ksi

Ready Mixes: 28d... in

Concrete: 4ksi

RebarSteel

StructuralSteel

Concrete: 5ksi

Ready Mixes: 4 k... in

Concrete: US|WA: 6 ksi

EC (Conservative) 74.7M kgCO2e

EC Intensity 485 kgCO2e/m2

EC (Conservative) 30.8M kgCO2e

Unit	EC	%
t	28.7M kgCO2e	98 %
m3	439k kgCO2e	2 %

EC (Achievable) 1.26M kgCO2e

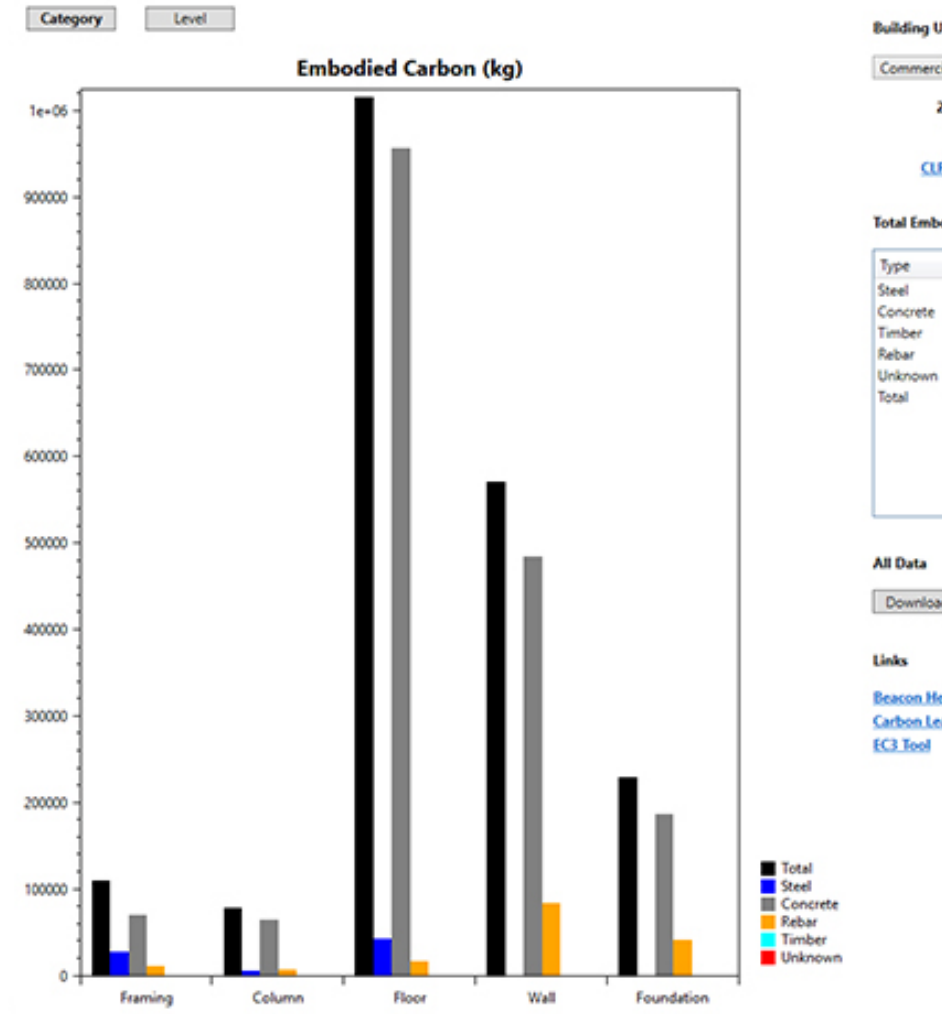
Unit	EC	%
t	1.13M kgCO2e	100 %

Organize quantities by Uniformat or custom organizations

Search Material * StructuralSteel 715 t 1.13M kgCO2e 100 %

EC3 Material Search find materials matching your design specs

Beacon



Product Declarations

“Nutrition” Label

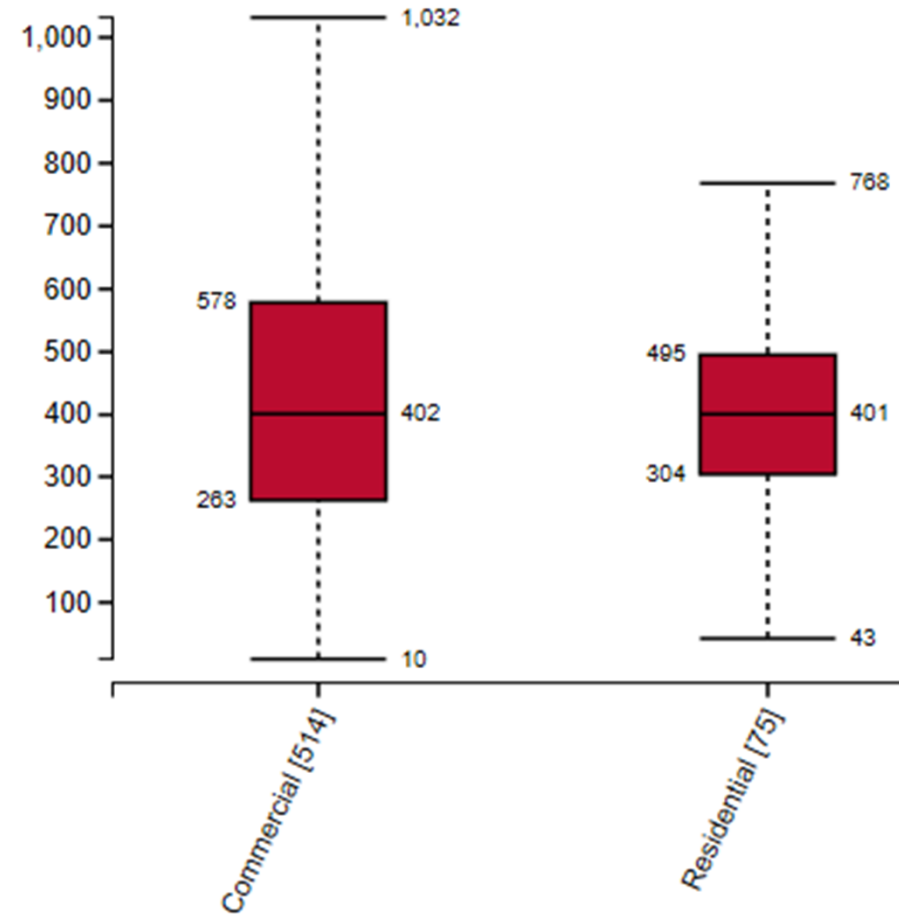
Building Product

per Unit

IMPACT MEASURES	TOTAL
Energy (MJ)	0.0
Global Warming Potential (kg CO ₂ eq)	0.0
Ozone Depletion (kg CFC- 11 eq)	0.0
Acidification Potential (mol H ⁺ eq)	0.0
Eutrophication Potential (kg N ⁻ eq)	0.0
Oxidant Creation Potential (kg O ₃ eq)	0.0

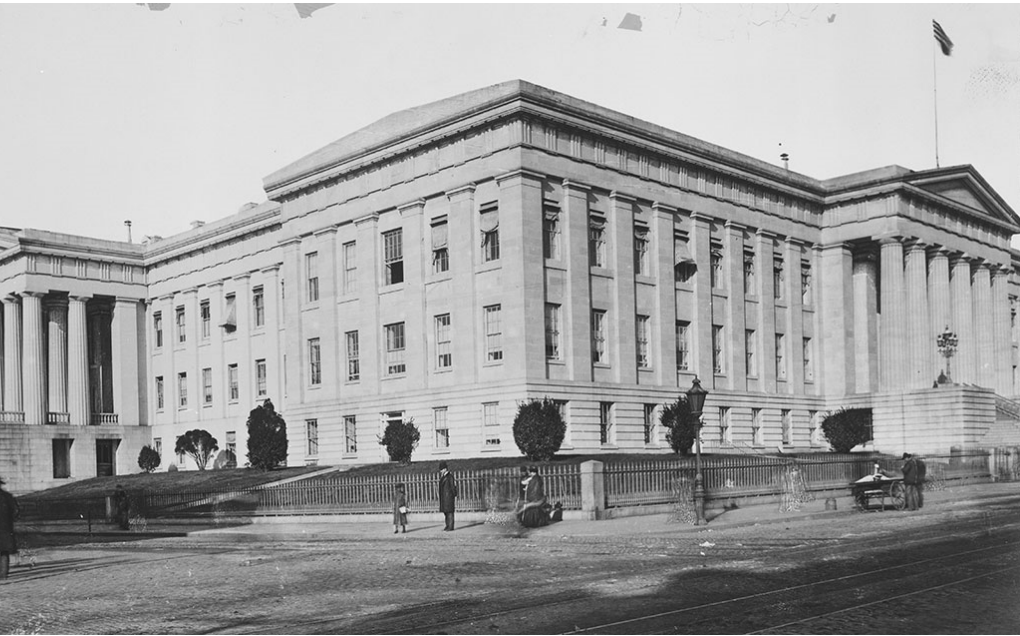
Product's Ingredients: Listed Here

Initial Embodied Carbon (kg-CO₂e/m²)

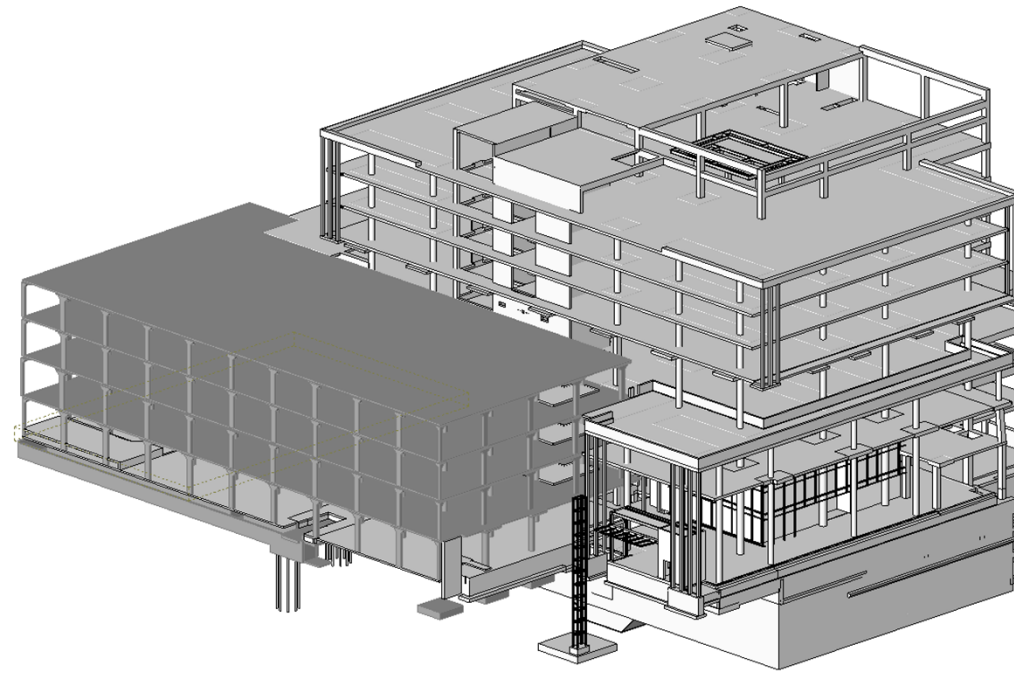


Courtesy: Carbon Leadership, Embodied Carbon Benchmark Study

Design - Resilience



Courtesy: U.S. Dept. of the Interior

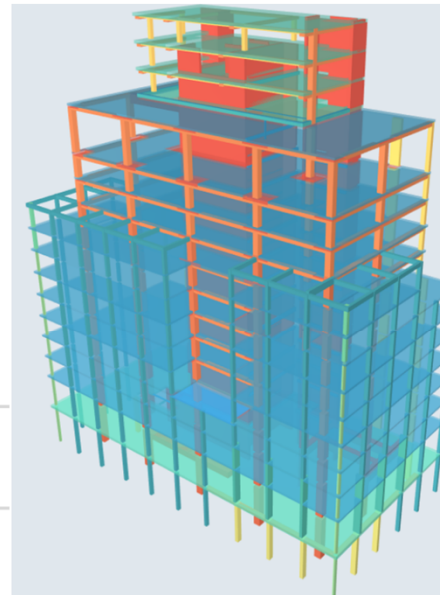
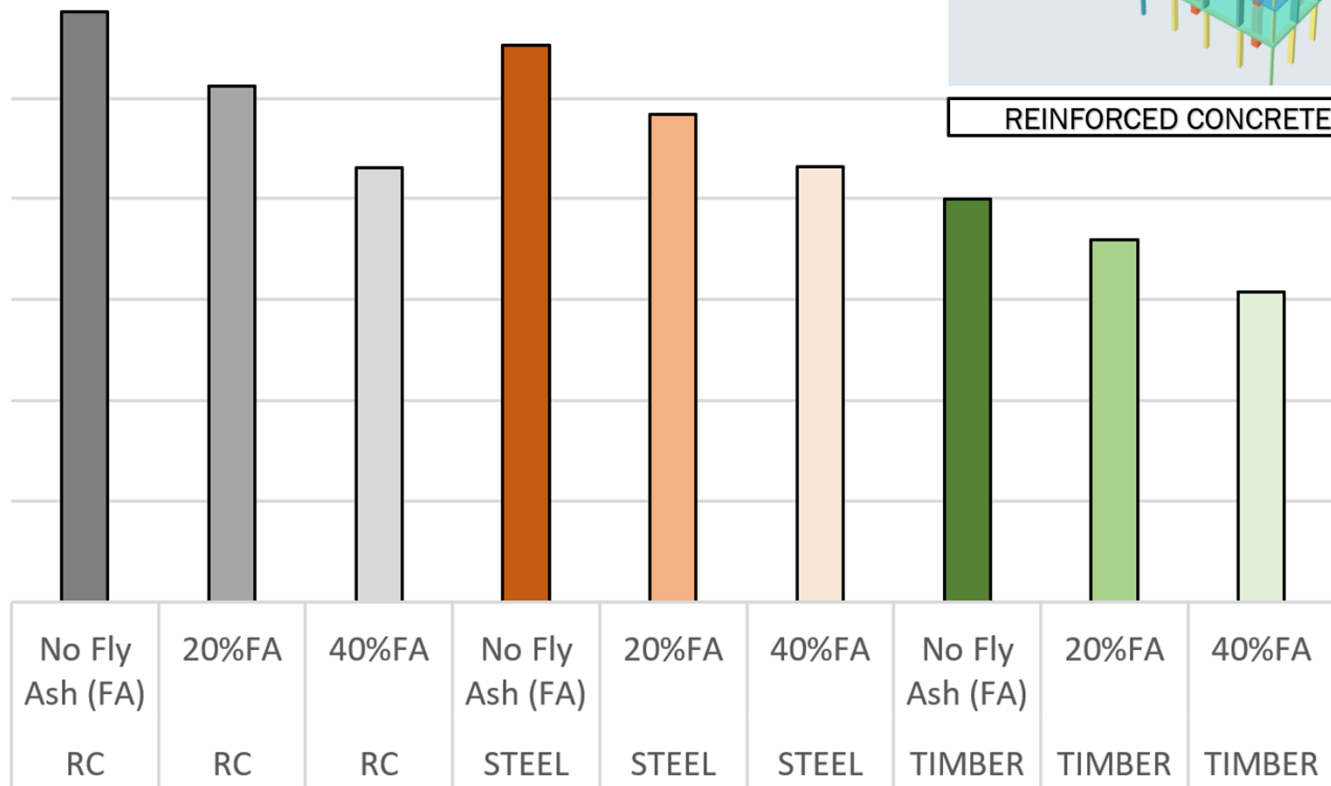


Courtesy: Shalom Baranes Associates

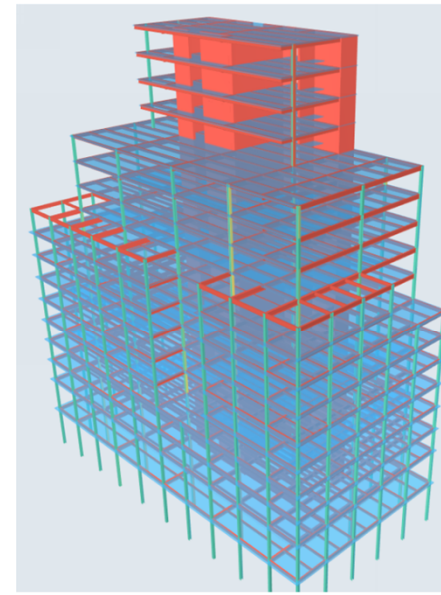


Material selection

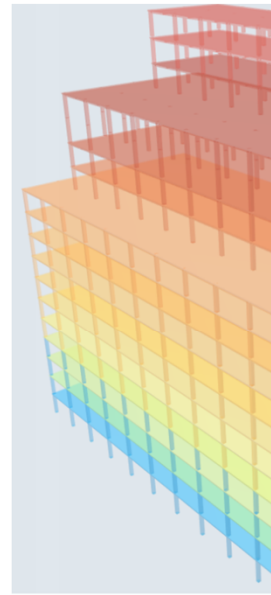
TOTAL EMBODIED CARBON



REINFORCED CONCRETE



STEEL



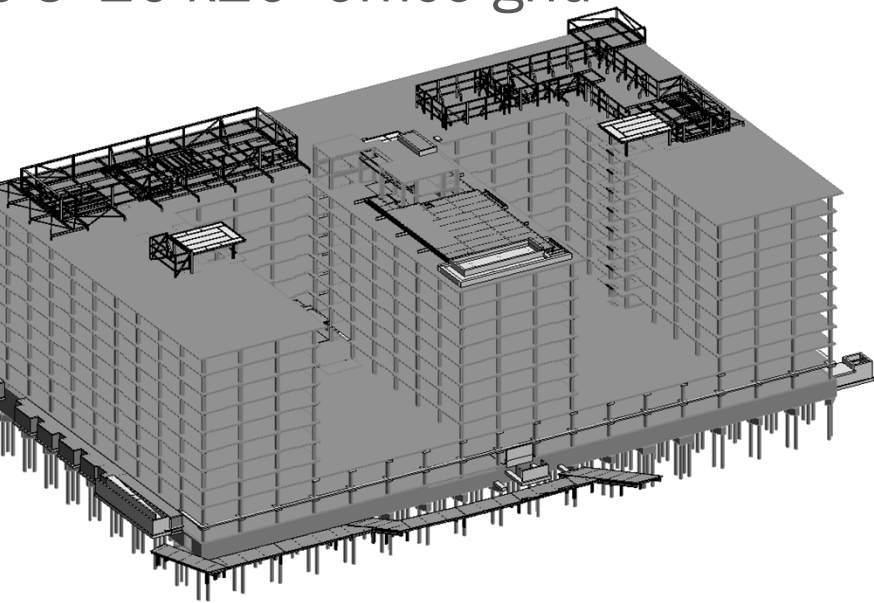
TIMBER

Courtesy: Emre Kalayci, Thornton Tomasetti

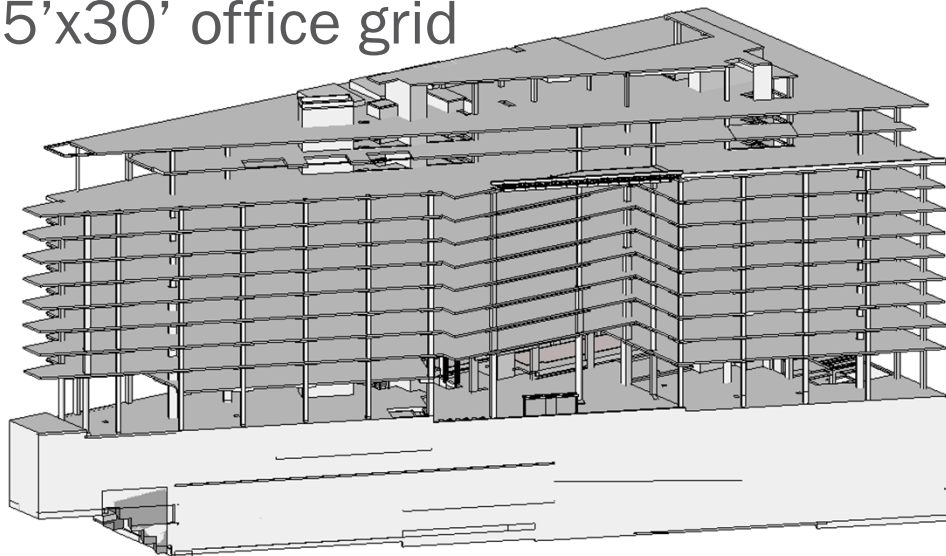
Courtesy: Emre Kalayci, Thornton Tomasetti

Design

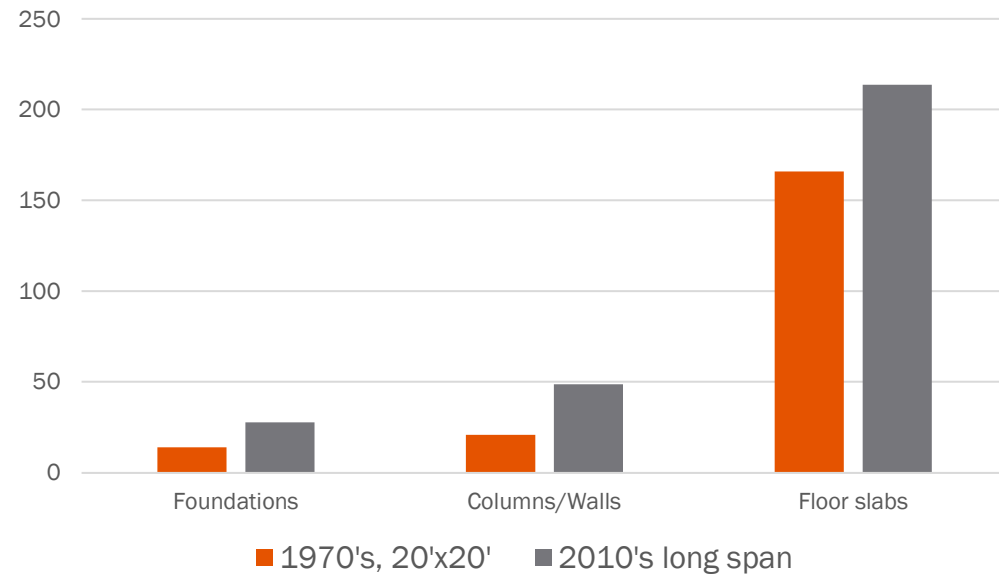
1970's 20'x20' office grid



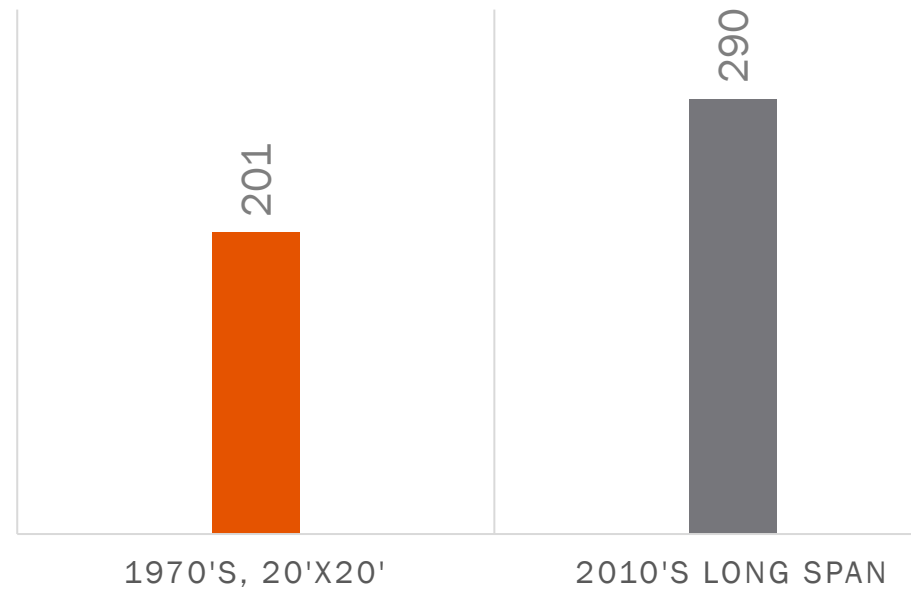
2010's 45'x30' office grid



By Structural Element kg-CO2e / m2

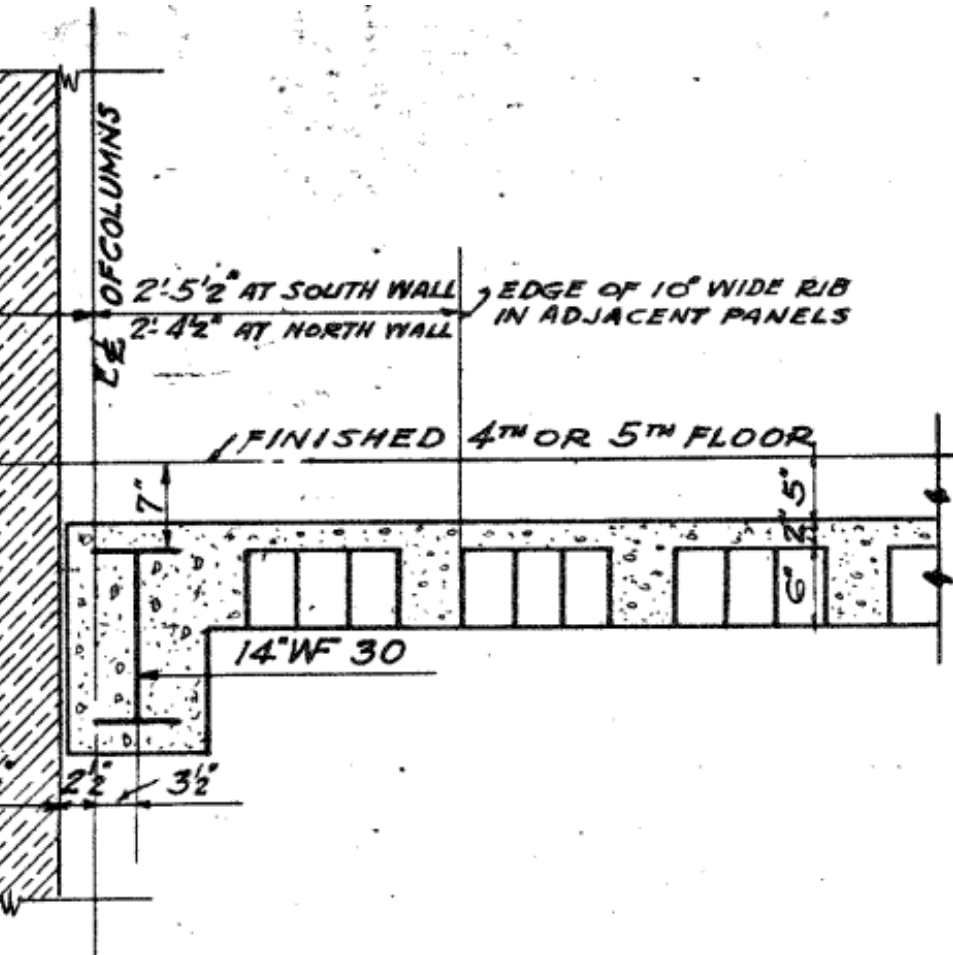


Overall kg-CO2e / m2

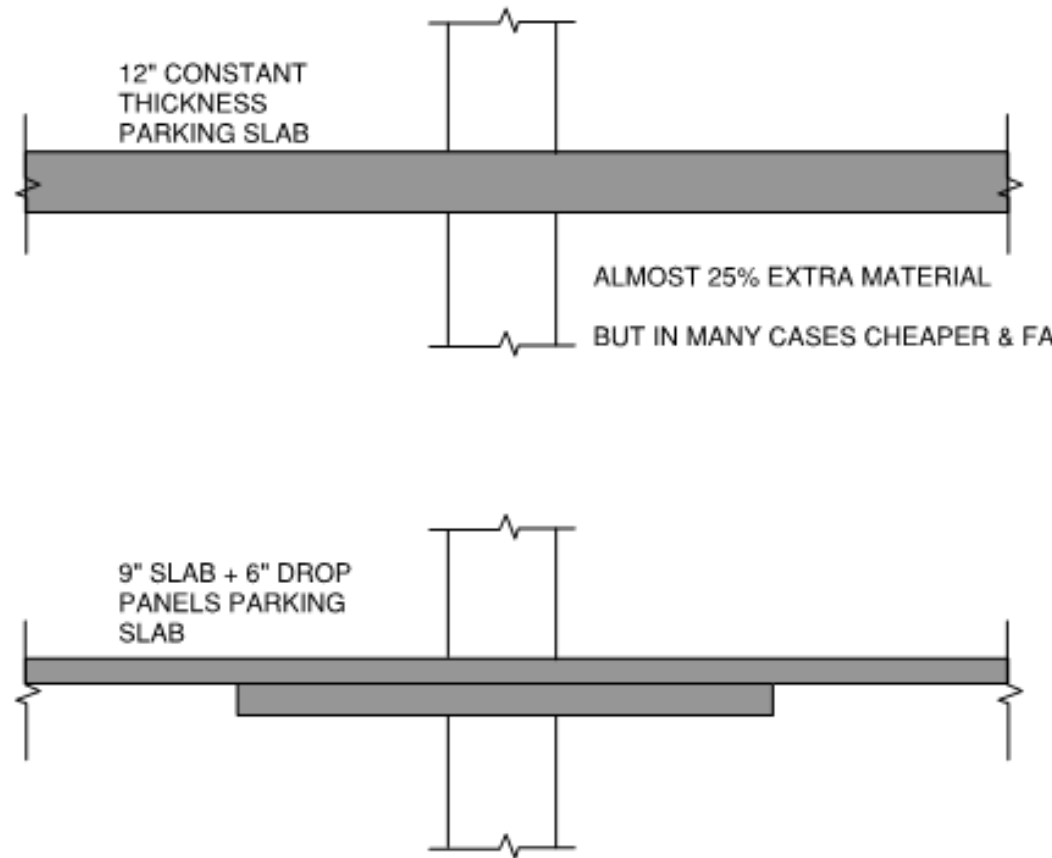


Material Efficiency – elevated slab example

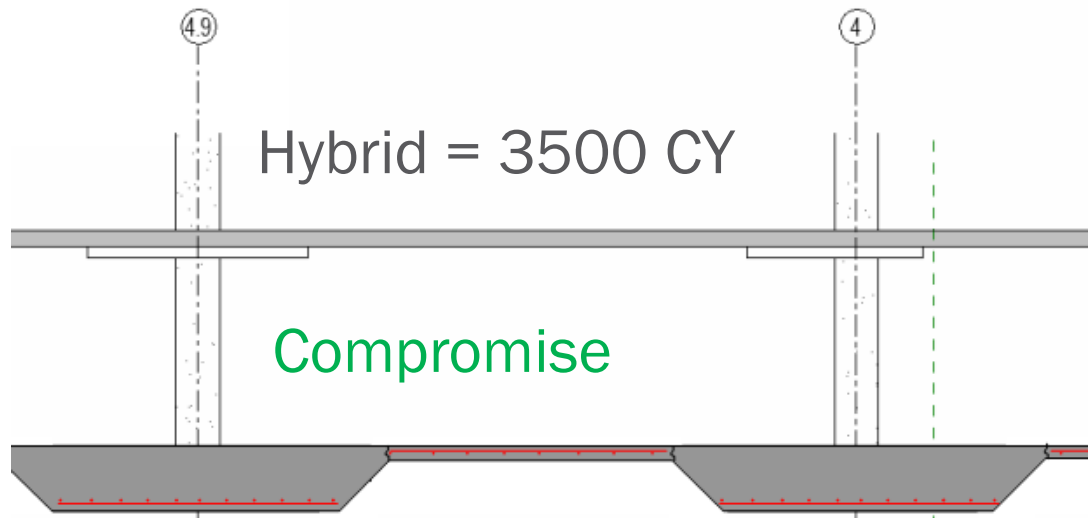
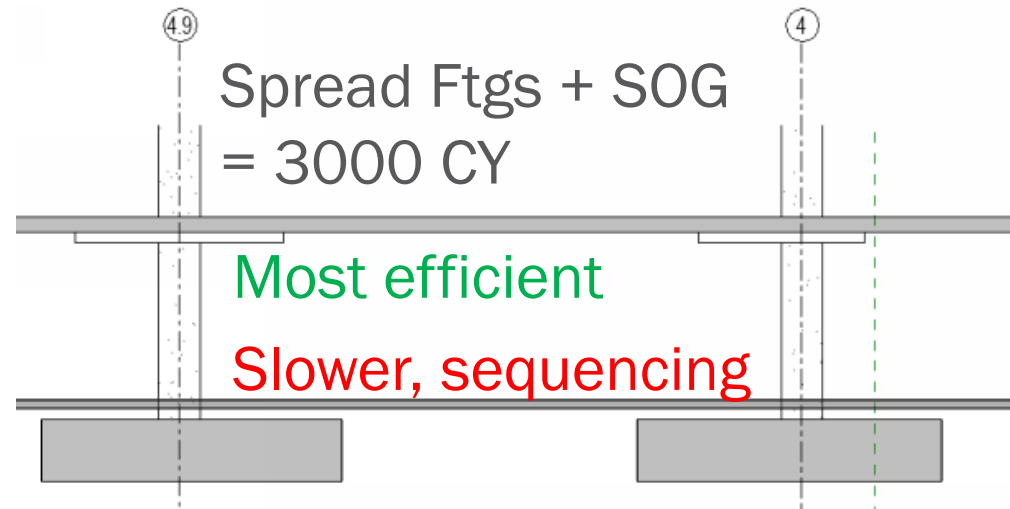
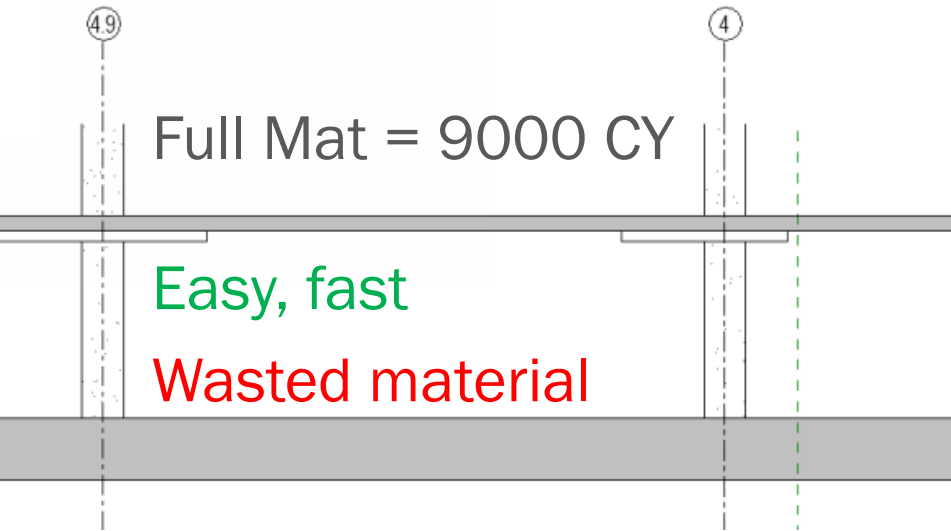
Washington DC Construction



Today



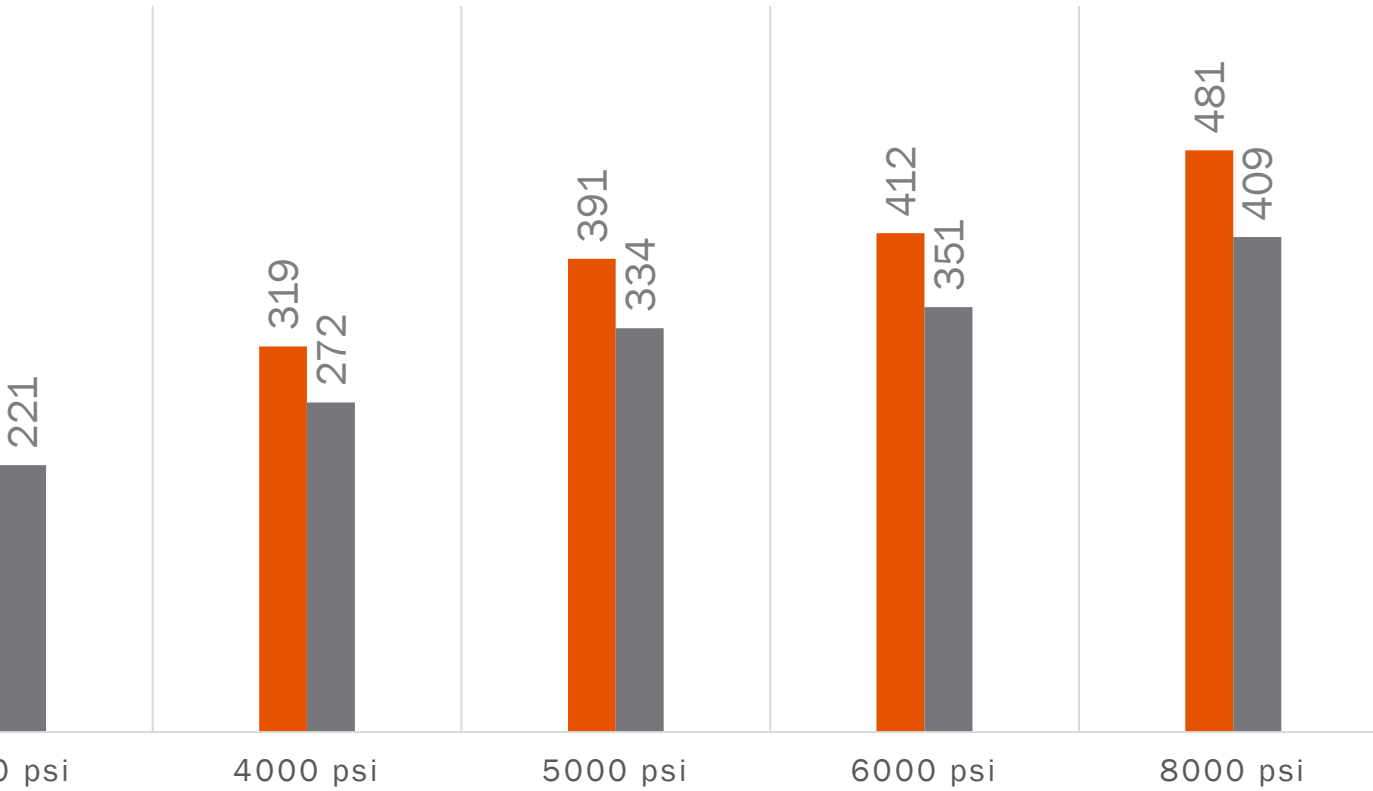
Material Efficiency – foundation example



Material Optimization

Effect of SCMs

■ No SCMs ■ 20% Fly Ash

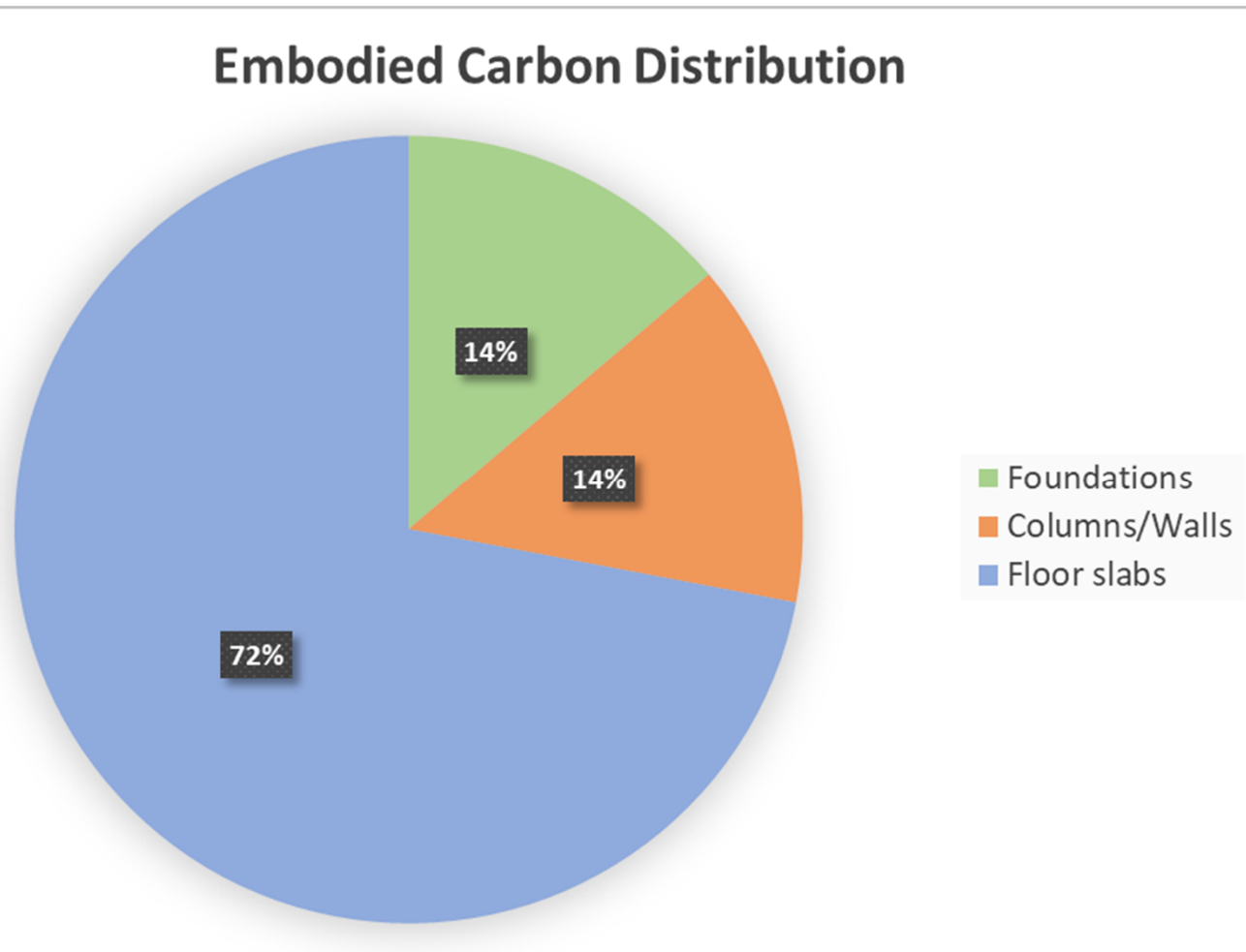


Source: National Ready Mix Concrete Association EPD 2016-2021



Material Optimization

the tower on podium example



Slabs are the largest contributor

1. High early strength
2. Usually no SCMs

5000 psi PT slabs

a. 3000 @ 2 days

b. >8000 @ 28 days

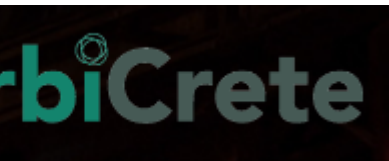
=25% more embodied carbon
than required by the design

Recent Advances



Concrete, LLC

CO2 sequestration + cement replaced with Portlandite



CO2 sequestration + cement replaced with blast furnace slag



CO2 sequestration. Claim about 11 kg/cy carbon reduction (3%-5%)

SOLIDIA*

Combines energy reductions from cement production with carbon-bath curing of concrete

What story we will tell?

130 involvement and vision

Industry support: EPDs, carbon sequestration, mix designs, new technologies

Creative thinking: owners, design professionals, contractors, suppliers, industry officials, researchers, innovators



Courtesy: Thornton Tomasetti

Questions?

Welcome to The Embodied Carbon Lab

Since 2011 the TT Embodied Carbon Laboratory has been contributing to industry research on embodied carbon in structures and developing pathways and tools for introducing strategies to reduce embodied carbon in our own projects. Please join in on building Thornton Tomasetti's leadership in this emerging area.

THE EMBODIED CARBON TEAM

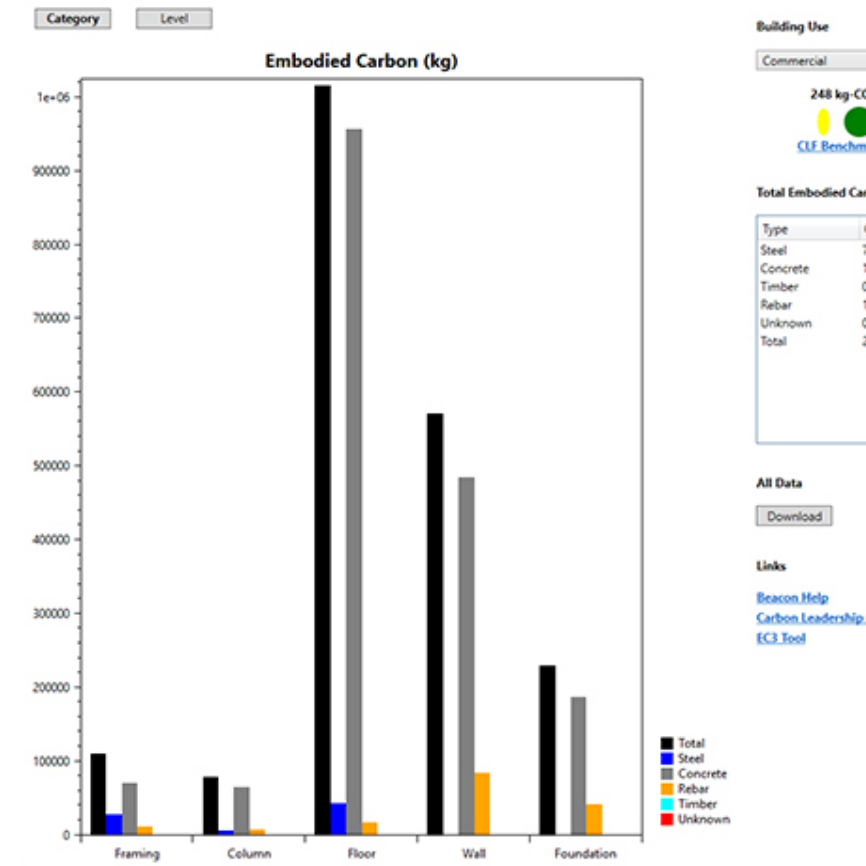
- Amy Hattan**
Vice President of Corporate Sustainability
- Duncan Cox**
Associate Sustainability
- Alexandra Davis**
Sustainability Intern

GUIDING LINKS & DOCUMENTS

- Carbon Leadership Forum
- Join the Carbon Leadership Forum
- Life Cycle Analysis Practice Guide
- Embodied Carbon Benchmark Study
- Carbon as a Design Criteria
- Sustainability Best Practices for Engineers
- Athena Sustainable Materials Institute
- Embodied Carbon in Construction

LATEST BLOG POSTS

- Recent Articles on Embodied Carbon
Amy Hattan 2 months ago
- Embodied Carbon: The Blindspot of the Buildings Industry
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- Interested in joining the SEI Sustainability Committee of ASCE?
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- Embodied Carbon Policy in the U.S.
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