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The magazine for civil & structural engineers

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Sustainable and Resilient Structural Design Using RAM Software

June 21, 2022

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Introduction

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Seth Guthrie
Director, User Success
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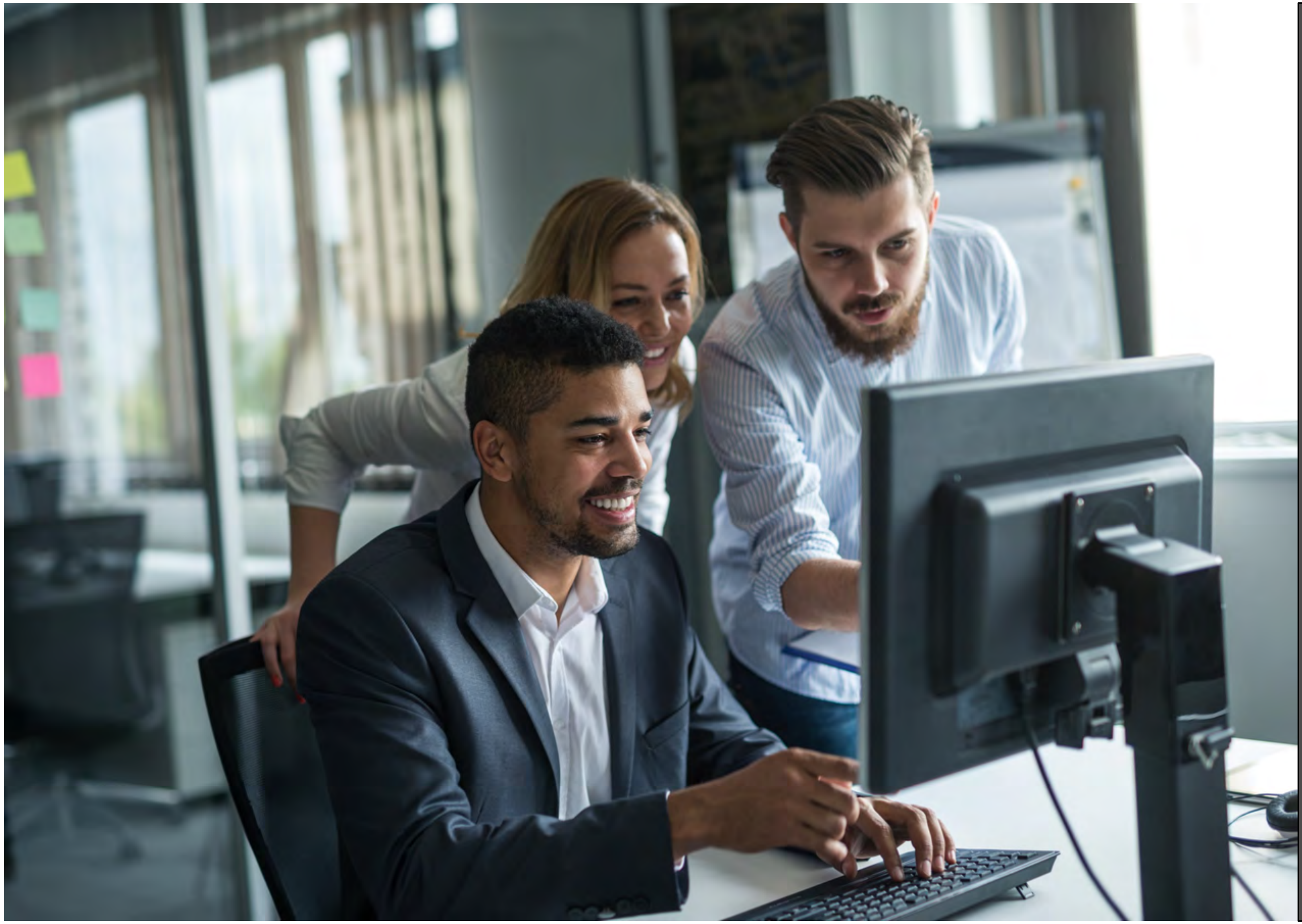
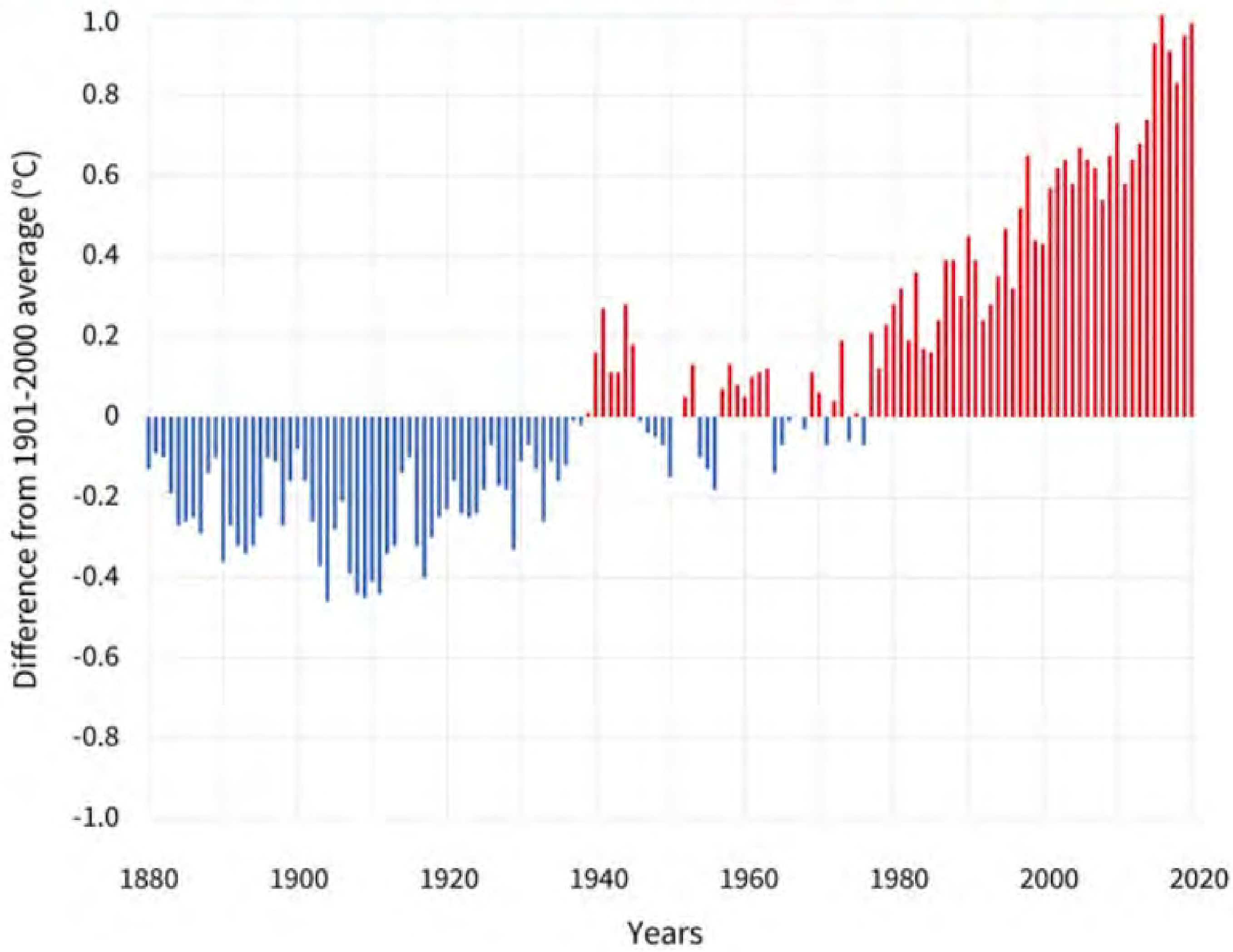
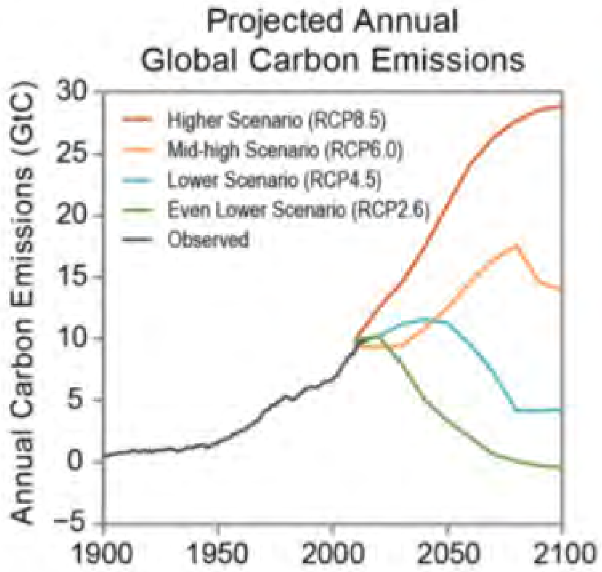
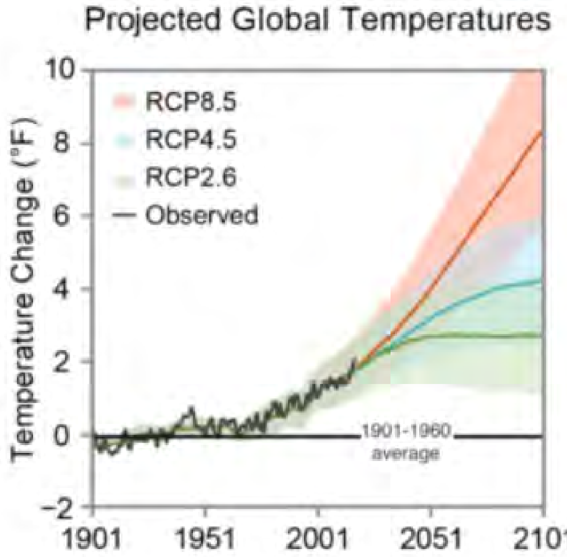


Sustainable and Resilient Structural Design Using RAM Software

GLOBAL AVERAGE SURFACE TEMPERATURE







Source: NOAA Climate.gov

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"The built environment generates nearly 50% of annual global CO2 emissions."

- Architecture 2030

Global building floor area is expected to double by 2060.

Equivalent of adding an entire New York City to the world every month.

Source – Architecture 2030

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AIA CONTINUING EDUCATION

architecture 2030

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ASCE
STRUCTURAL ENGINEERING INSTITUTE

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COMMITTING TO ZERO

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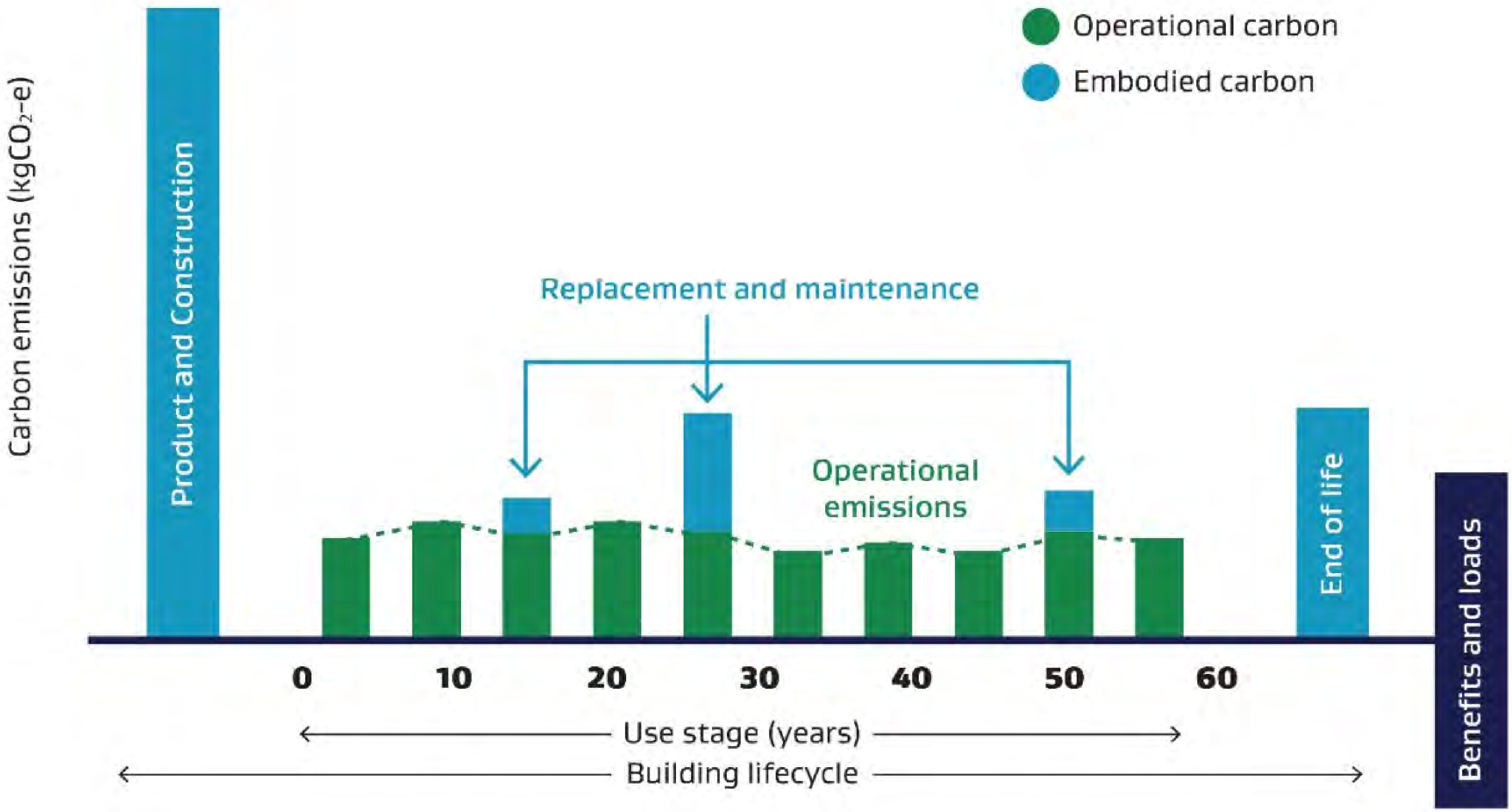
"For everyone working in the construction industry, meeting the needs of our society without breaching the earth's ecological boundaries will demand *a paradigm shift* in our behaviour."

www.structuralengineers.declare.com

UK Structural Engineers Declare Climate & Biodiversity Emergency

Image Credit – SKANSA USA



Source: London Energy Transformation Initiative, LETI Embodied Carbon Primer, January 2020.

Embodied Carbon (lb CO2eq) = Material Quantity x Carbon Factor

Gravity Beam Design Takeoff

Bentley

RAM Steel 17.03.01.50
DataBase: Tutorial_v1703_US
Building Code: IBC
Steel Code: AISC 360-16 LRFD

STEEL BEAM DESIGN TAKEOFF:

Floor Type: Roof
Story Level 5
Steel Grade: 50

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
W8X10	17	355.80	3584
W10X12	6	120.20	1448
	23		**5032**

Total Number of Studs = **0**

Floor Type: Typ
Story Levels 3 to 4
Steel Grade: 50

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
W8X10	35	700.00	7051
W10X12	29	695.00	8372
W12X14	4	100.00	1416

Lifecycle Stage	Module
Raw Material Production	A1, A2, A3
Material Transport to Site	A4
Construction	A5

ENVIRONMENTAL IMPACTS

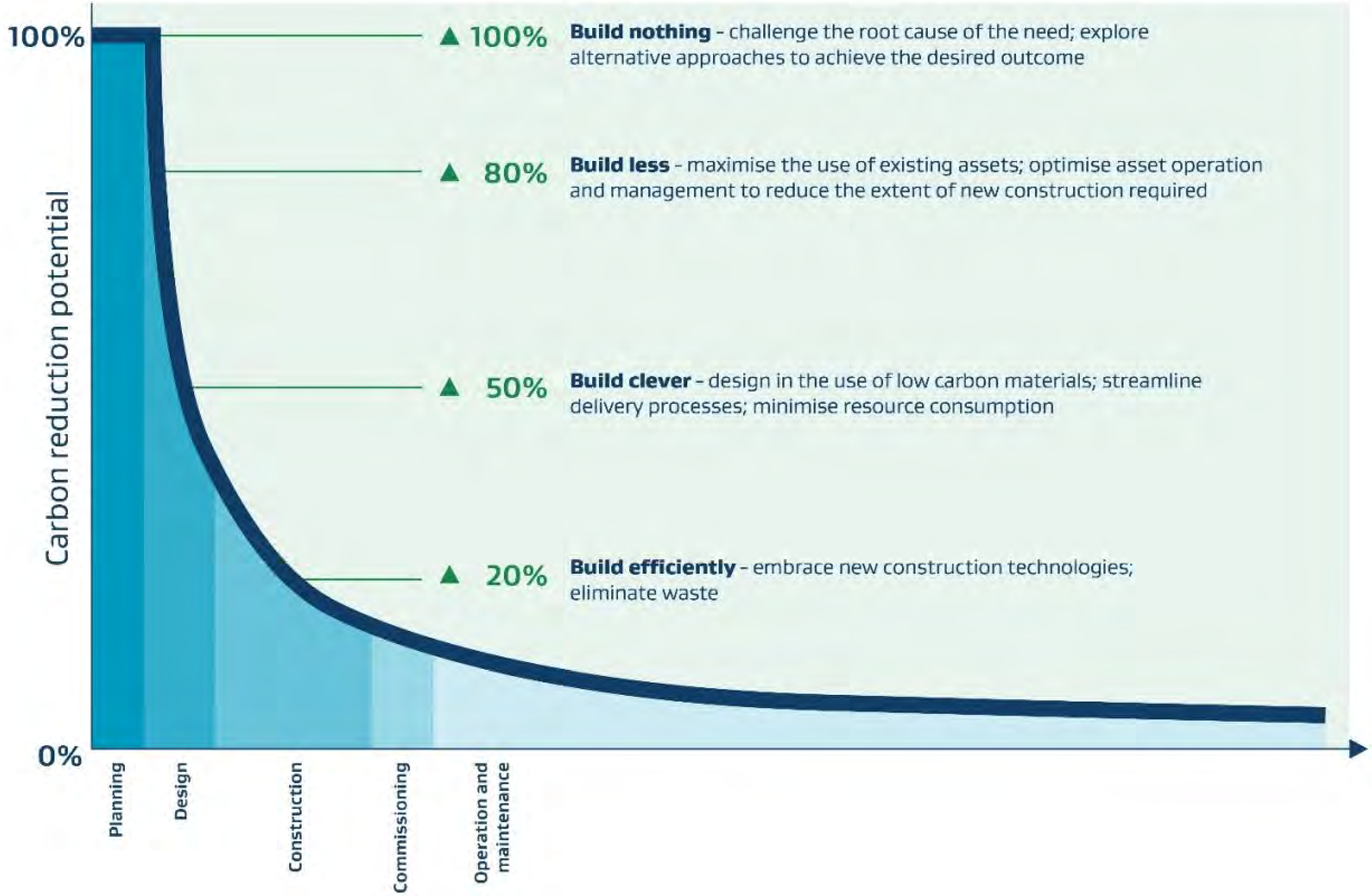
Declared Product:
Mix PN4888 • Quivas Plant
Description: 4,000 Non-Air Entrained
Compressive strength: 4000 PSI at 28 days

Declared Unit: 1 m^3 of concrete

Global Warming Potential (kg CO_2-eq)	457
Ozone Depletion Potential (kg CFC-11-eq)	1.19E-5
Acidification Potential (kg SO_2-eq)	1.36
Eutrophication Potential (kg N-eq)	0.55
Photochemical Ozone Creation Potential (kg O_3-eq)	28.0
Abiotic Depletion, non-fossil (kg Sb-eq)	8.00E-6
Abiotic Depletion, fossil (MJ)	503
Total Waste Disposed (kg)	3.76
Consumption of Freshwater (m^3)	0.63

Product Components: natural aggregate (ASTM C33), Portland cement (ASTM C150), admixture (ASTM C494), batch water (ASTM C1602)

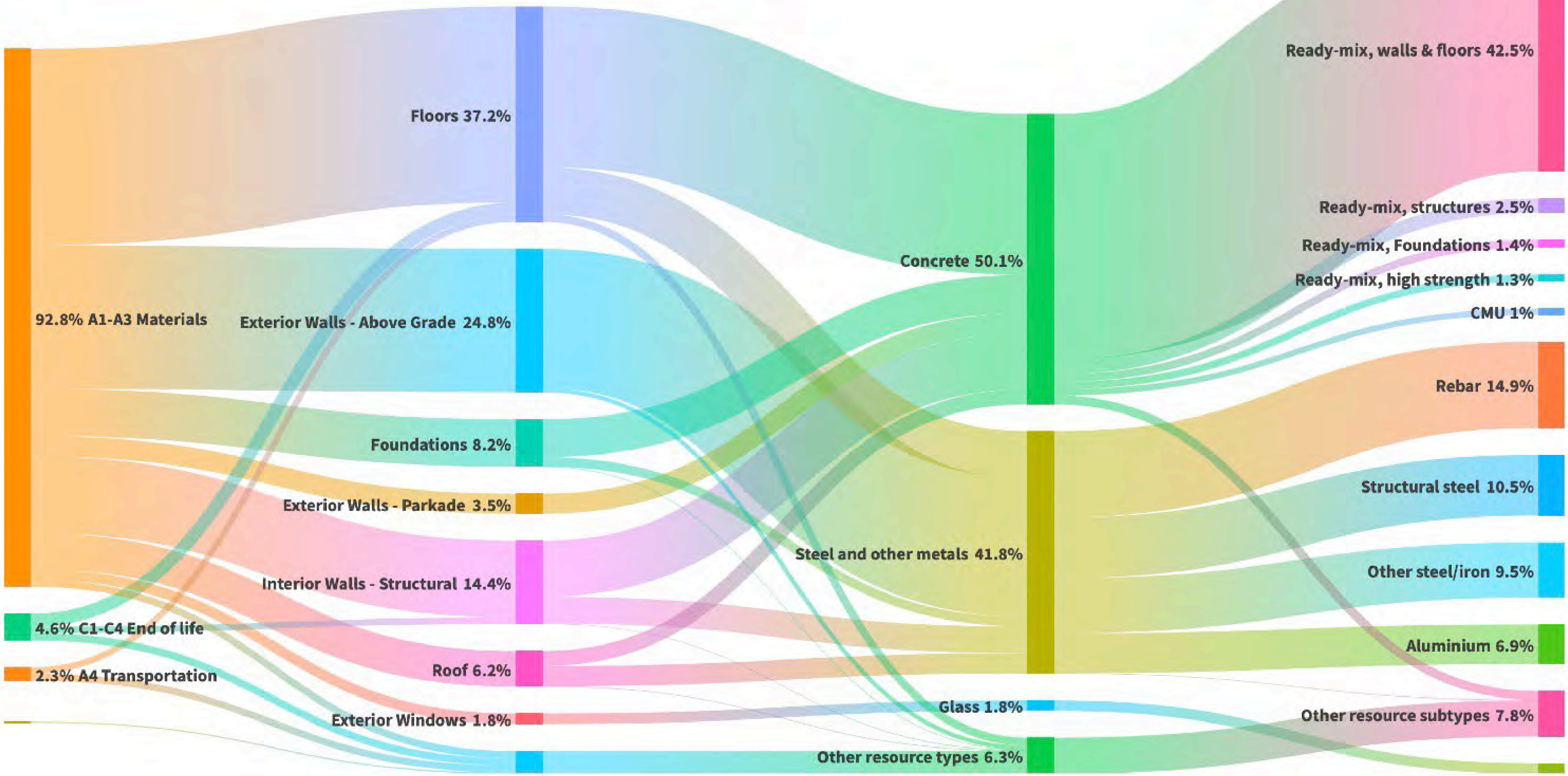
Additional detail and impacts are reported on page three of this EPD



Source: Green Construction Board after HM Treasury, Infrastructure Carbon Review, (Nov 2013)

"Just three materials – concrete, steel, and aluminum – are responsible for 23% of total global emissions (most from the built environment)."

Architecture 2030



Source: Priopta (www.priopta.com)

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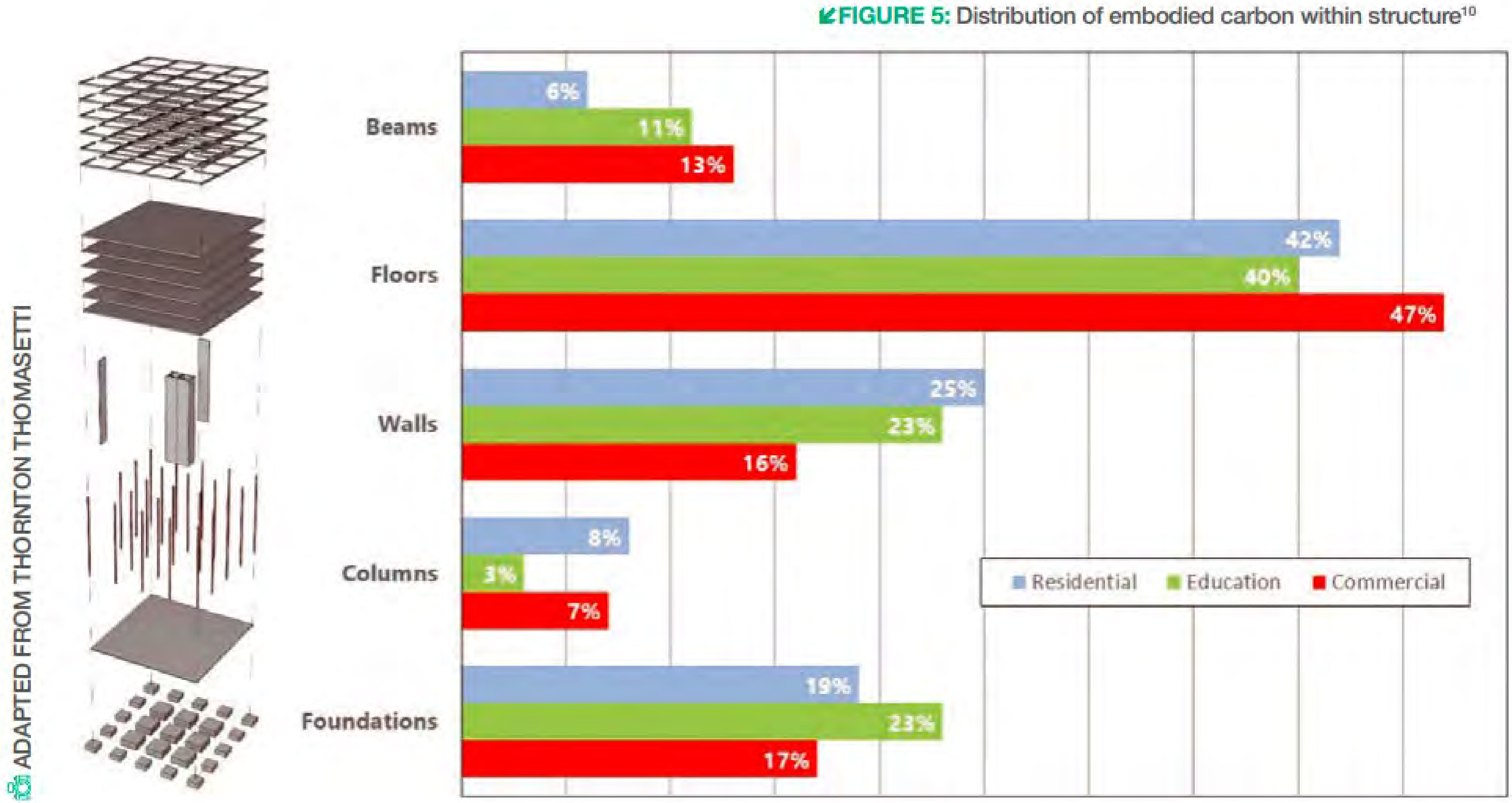

Source – Watson, Natasha. "Lean Design: 10 Things to Do Now." *The Structural Engineer*, August 2020.

Strategies for Sustainable Structural Designs

- Use More Sustainable Structural Materials
- Sustainable Material Specification
- Limit Overdesign
- Design for Long-Term Effects
- Design for Resiliency
- Life Cycle Assessment

Poll Question

What strategies are you using to deliver more sustainable structural designs (select all that apply)?

- Designing with Mass Timber
- Specifying Cement Replacements for Concrete Mix Designs
- Limiting Overdesign (Highly Optimized Designs)
- Calculating Embodied Carbon
- None of the above

Engineering Constraints

- Code Compliance
- Project Budget
- Project Schedule
- Building Function
- Constructability
- Embodied Carbon

Bentley's mission is to provide ***innovative software and services*** for the enterprises and professionals who ***design, build, and operate*** the world's infrastructure – sustaining the global economy and environment for ***improved quality of life***

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RAM Brand

RAM Structural System
3D analysis and design of buildings

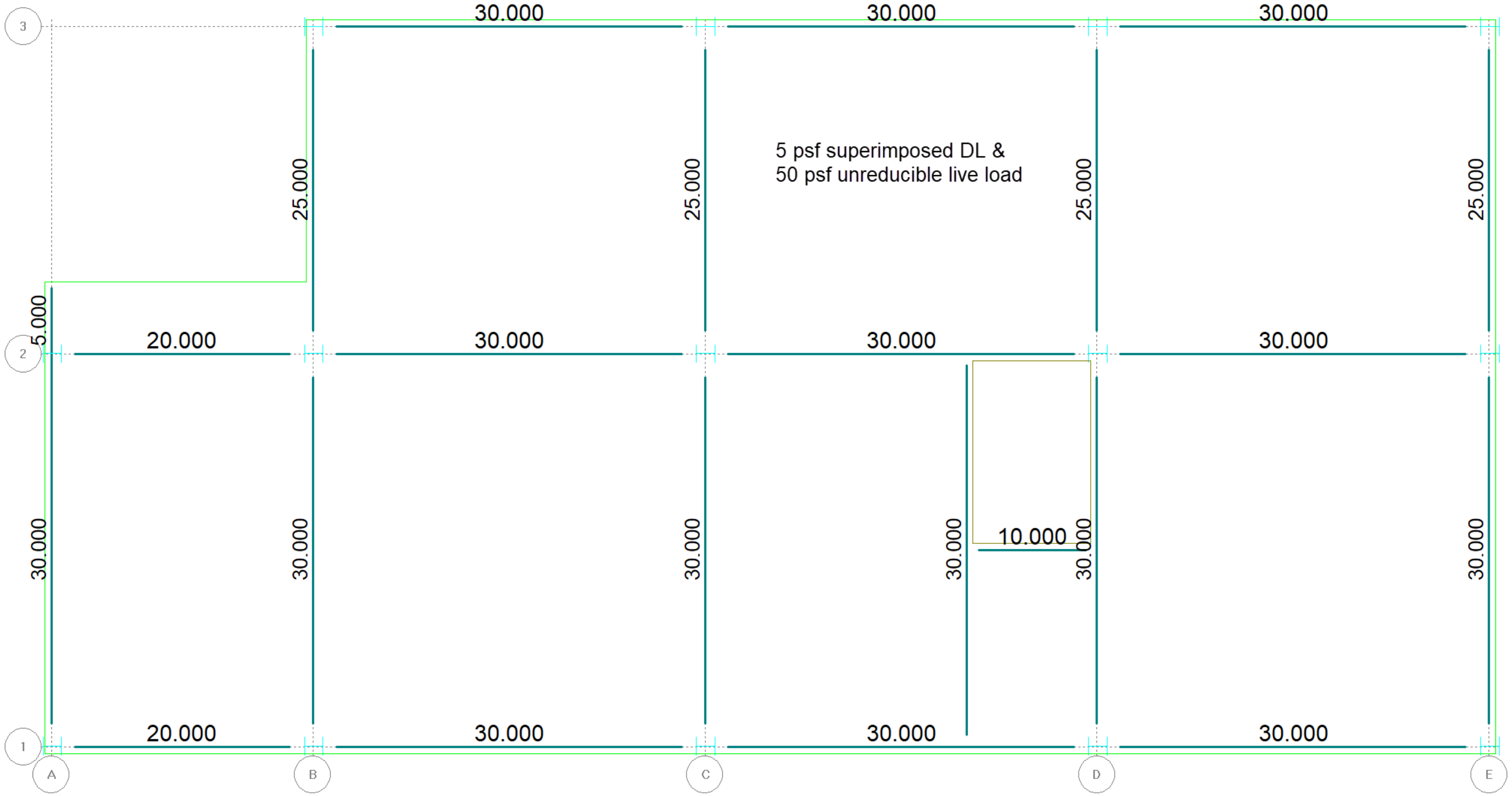
RAM Concept
Concrete slab and mat design (including post-tensioning)

RAM Connection
Structural steel connection design

RAM Elements
Design toolkits for structural components

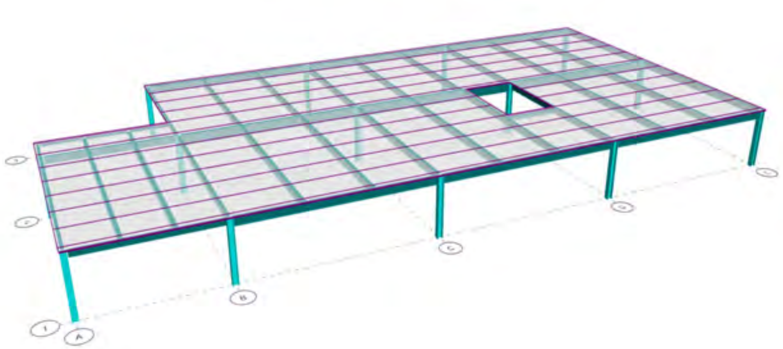
Office Floor Study Overview

- 5,816 sf
- 20 - 30’ bays
- 5 psf DL
  50 psf LL
- L/240 defl
- Office vibration and acoustics.



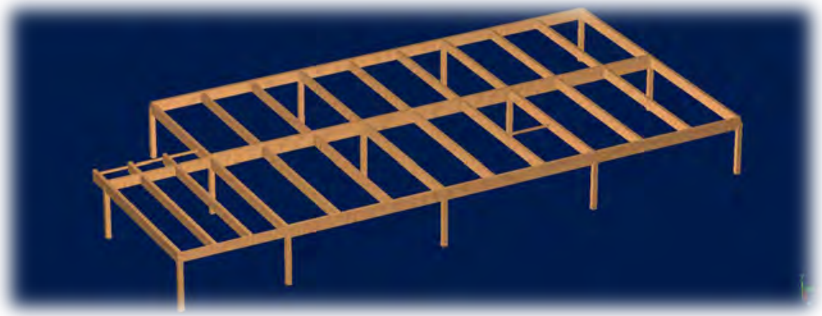
Office Floor Framing System Study

Scenario #1 – Composite Steel



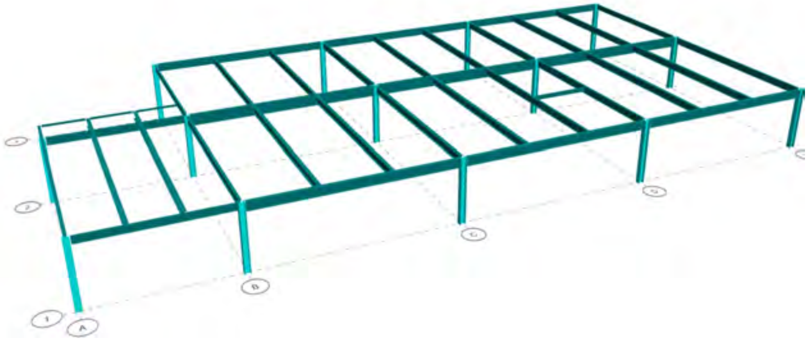
RAM Structural System

Scenario #2 – Glulam & CLT



RAM Elements

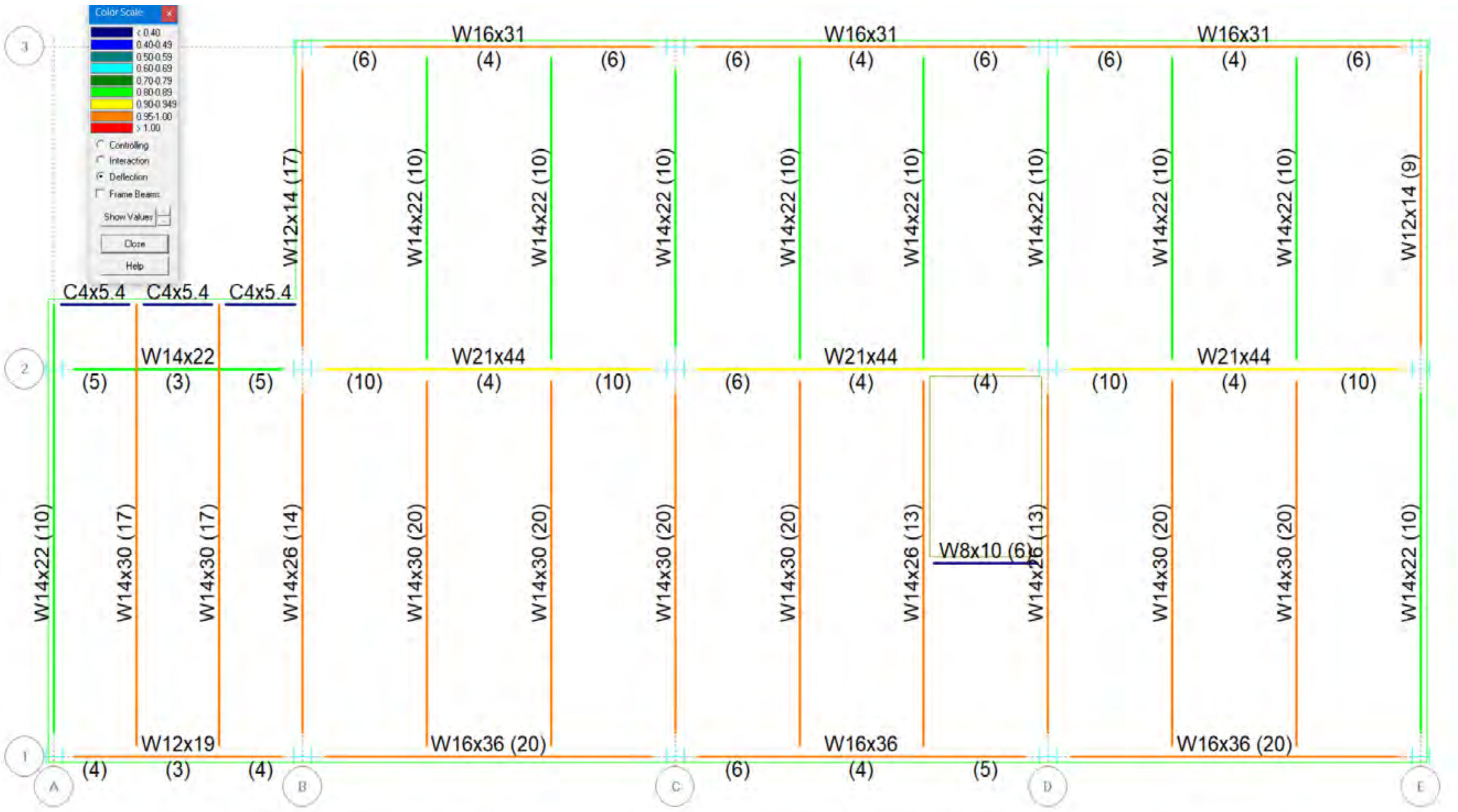
Scenario #3– Steel & CLT



RAM Structural System

Composite Steel option

- 3” concrete on 3” metal deck
- Deflection control
- Max depth 27”



Composite Steel option

- Total impact 196k
- 2/3 from concrete

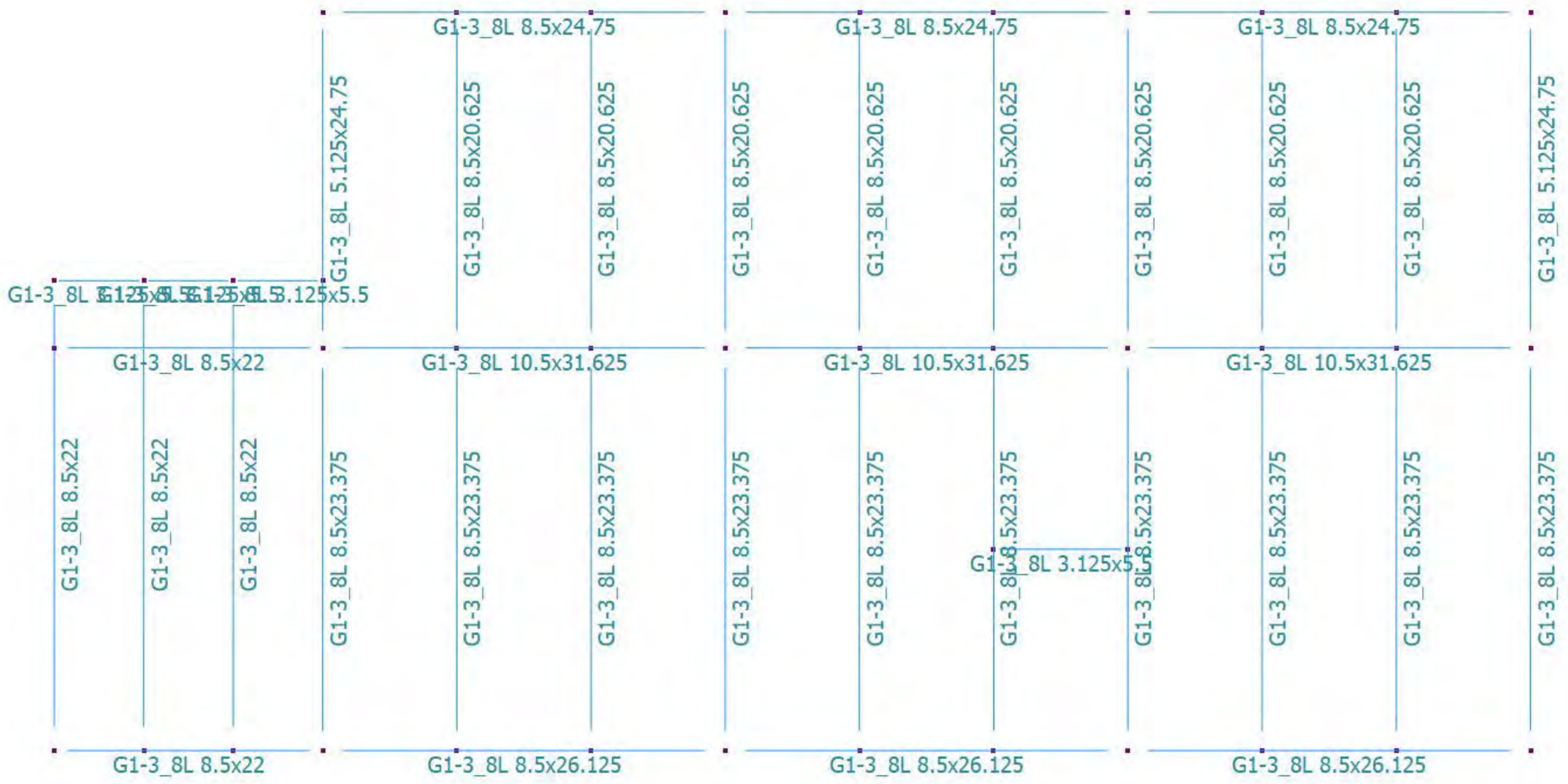
Embodied Carbon Area	
Total Area (ft^2)	5,816
Total Area (m^2)	540.31

Embodied Carbon Totals	
Total Impact (lb CO_2e)	196,088
Total Impact (kg CO_2e)	88,944

Embodied Carbon Intensities	
Intensity (lb CO_2e/ ft^2)	33.72
Intensity (kg CO_2e/ m^2)	164.62

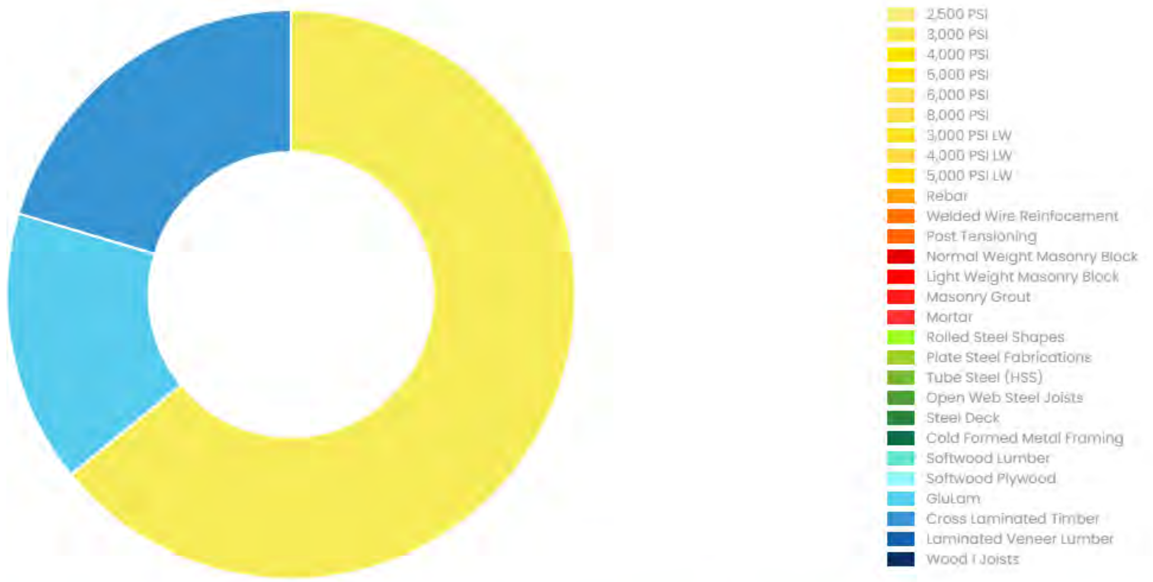
CLT & Glulam option

- 4.14” CLT with ½ gyp and 2” conc.
- Strength control
- Max depth 38”*



CLT & Glulam option

- Total impact 84k
- 2/3 from concrete



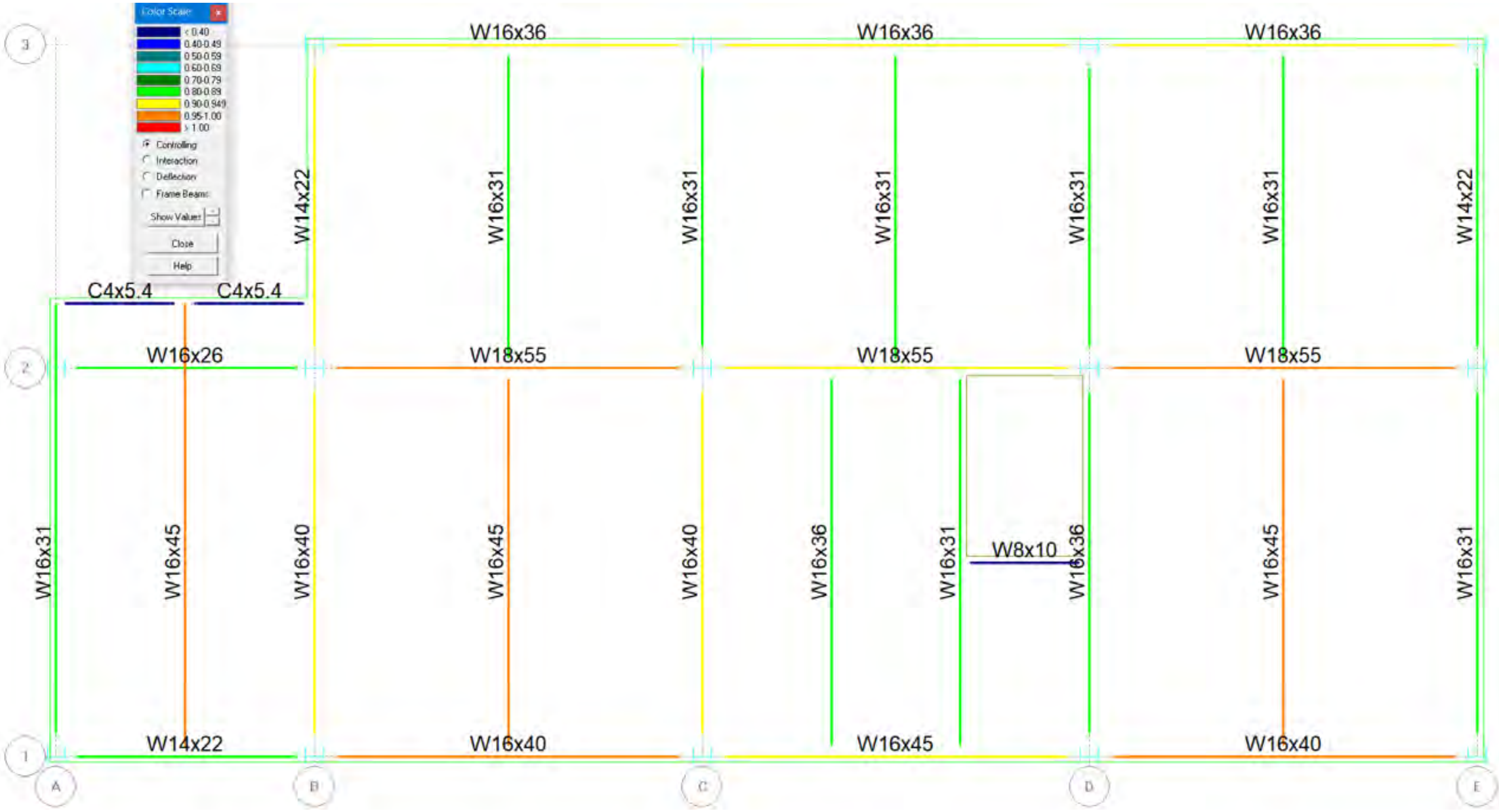
Embodied Carbon Area	
Total Area (ft^2)	5,816
Total Area (m^2)	540.31

Embodied Carbon Totals	
Total Impact (lb CO2e)	84,396
Total Impact (kg CO2e)	38,281

Embodied Carbon Intensities	
Intensity (lb CO2e/ ft^2)	14.51
Intensity (kg CO2e/ m^2)	70.85

Hybrid CLT & Steel option

- 5.47” CLT with ½ gyp and 2” conc.
- Wider bay, max 15’ (double span)
- Max depth 26”*



Hybrid CLT & Steel option

- Total impact 111k
- <1/2 from concrete

Embodied Carbon Area	
Total Area (ft²)	5,816
Total Area (m²)	540.31

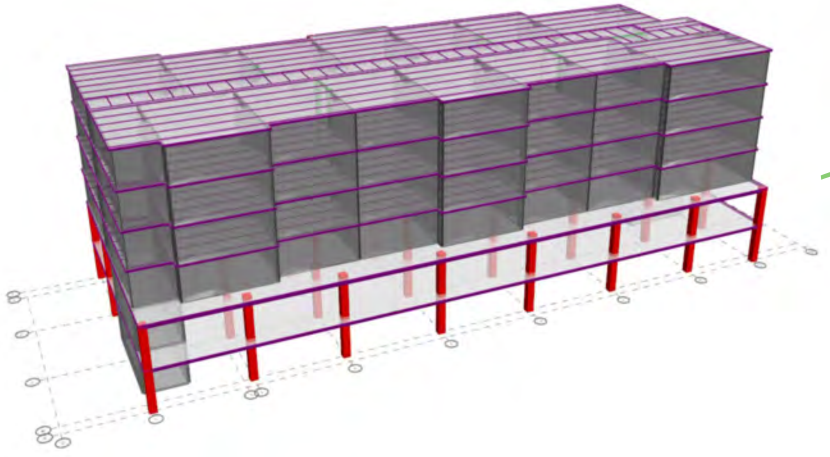
Embodied Carbon Totals	
Total Impact (lb CO2e)	111,355
Total Impact (kg CO2e)	50,509

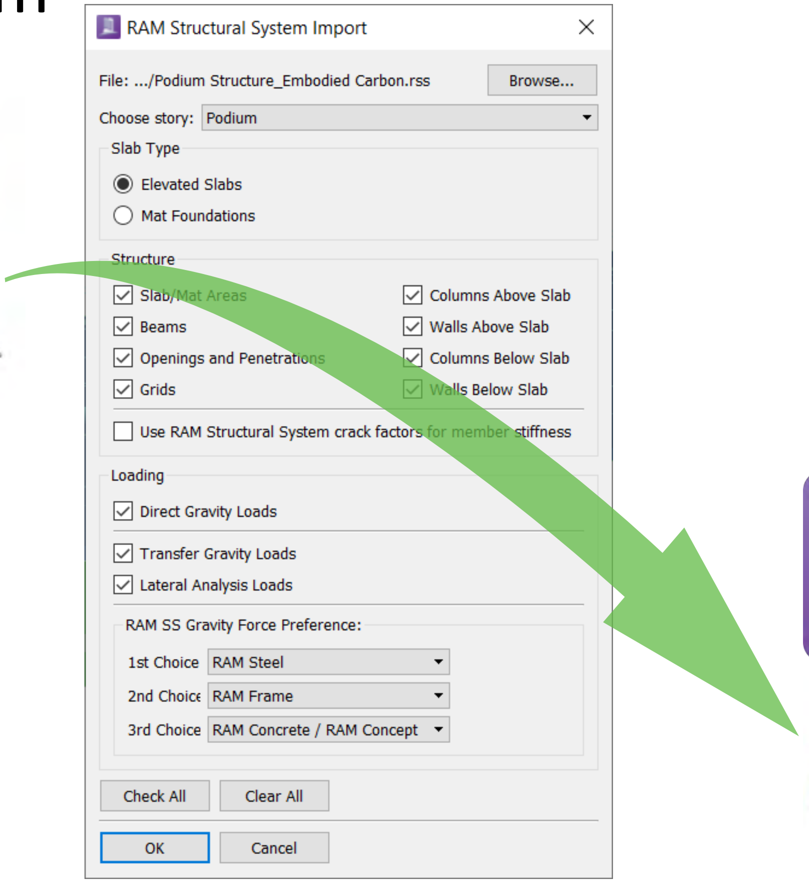
Embodied Carbon Intensities	
Intensity (lb CO2e/ ft²)	19.15
Intensity (kg CO2e/ m²)	93.48

Podium Structure – RC vs PT option

RAM Structural System

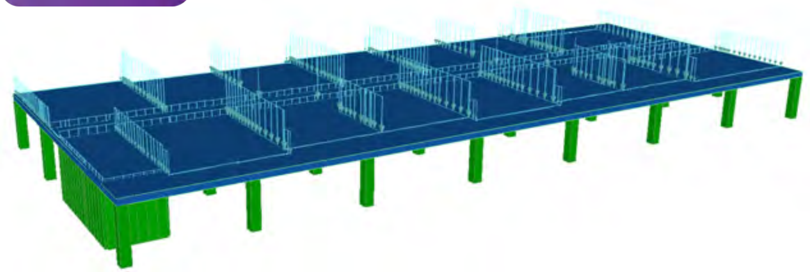
3D analysis and design of buildings

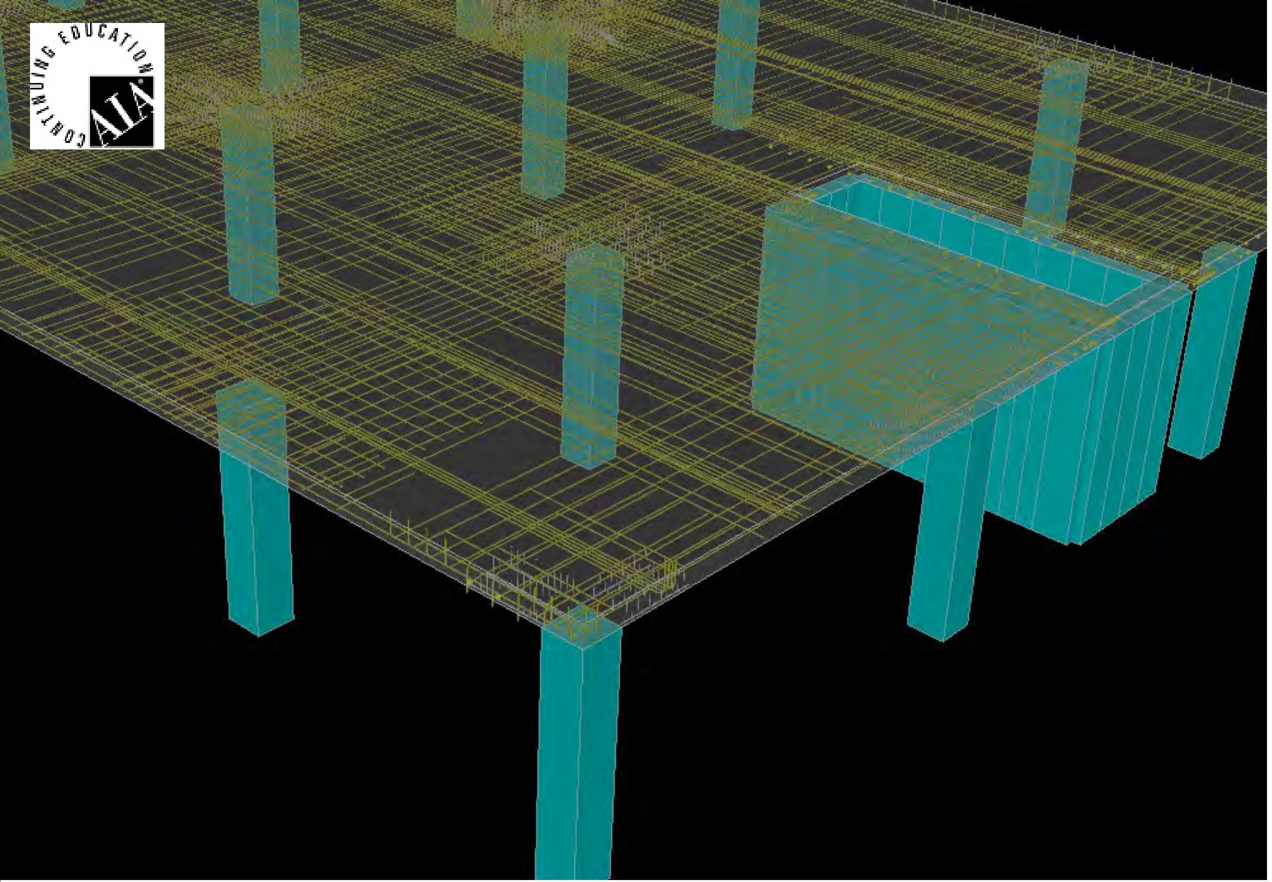


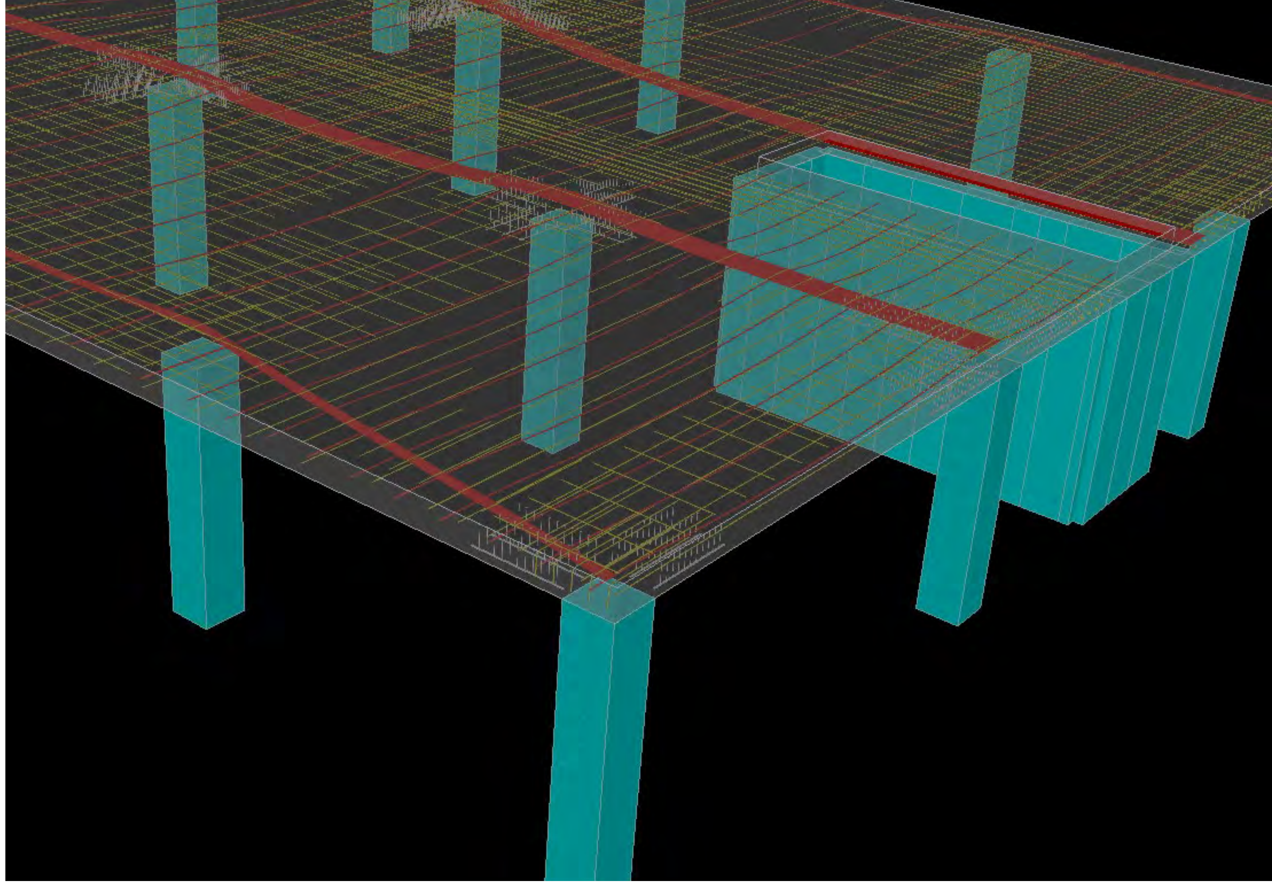


RAM Concept

Concrete slab and mat design







RC Slab

16” Slab Thickness

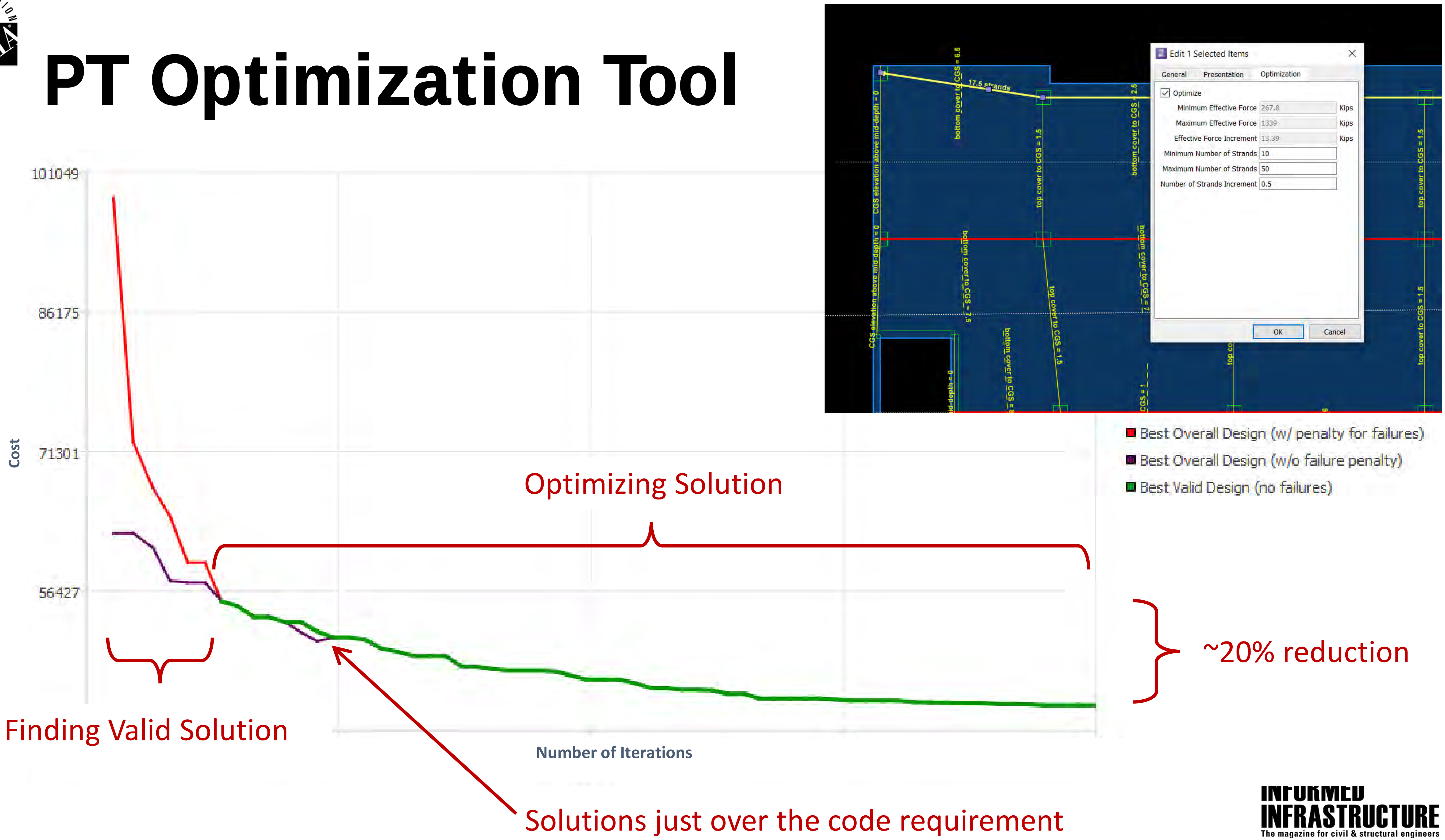
Embodied Carbon Totals	
Total Impact (lb CO2e)	590,131
Total Impact (kg CO2e)	267,681

PT Slab

13” Slab Thickness

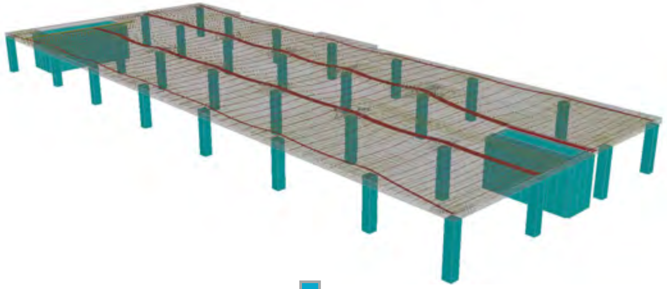
Embodied Carbon Totals	
Total Impact (lb CO2e)	413,482
Total Impact (kg CO2e)	187,554

PT Optimization Tool

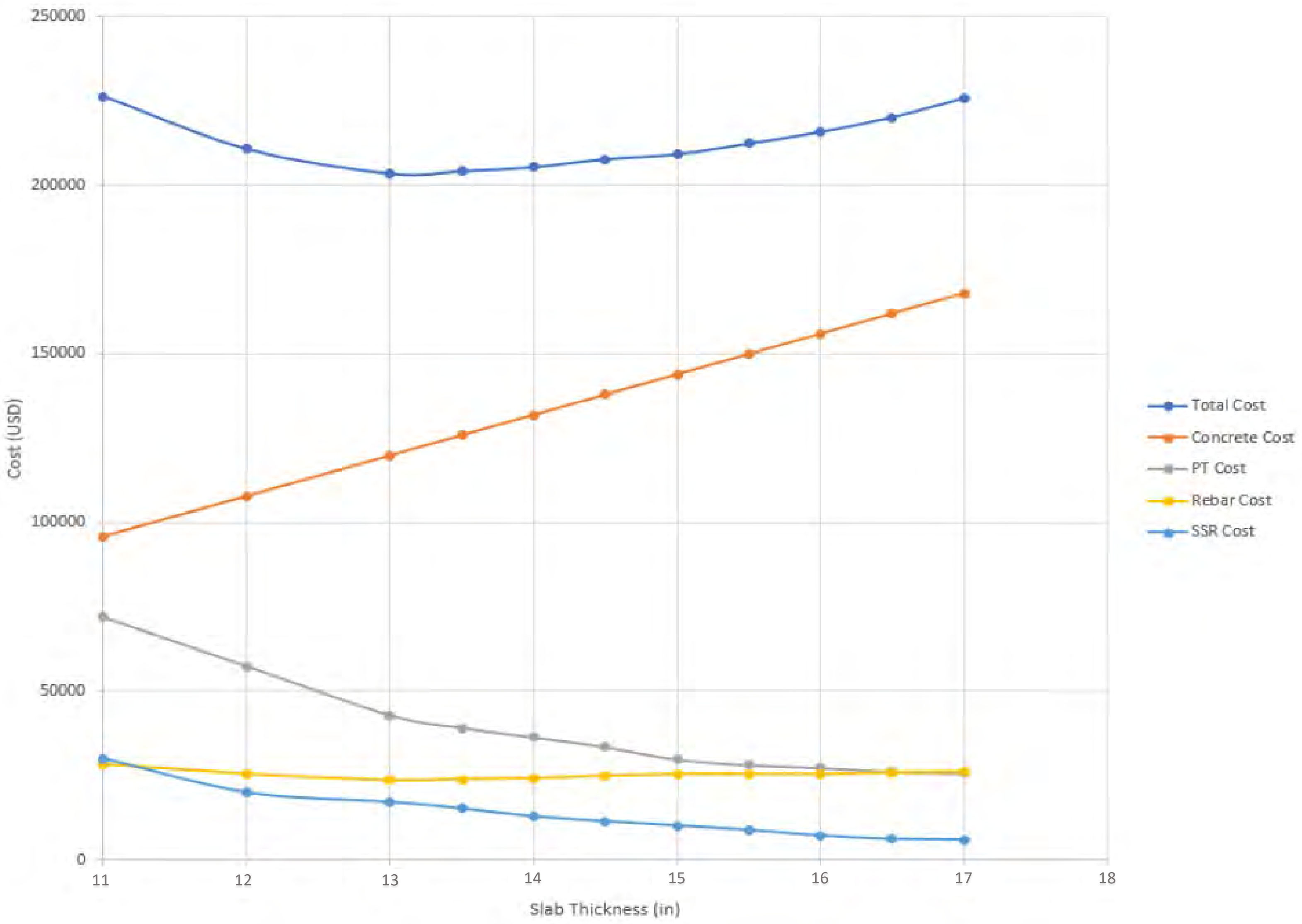


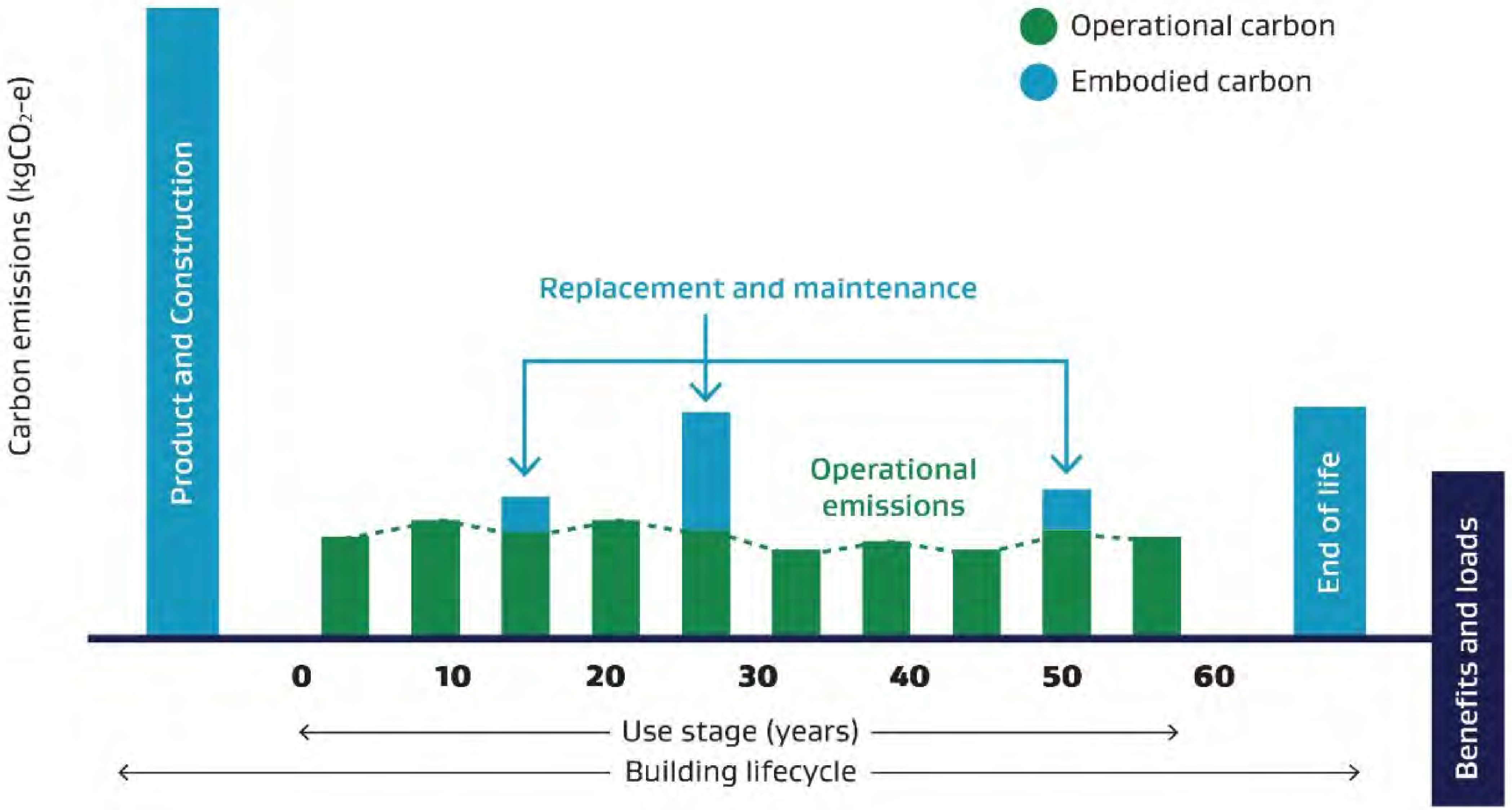
Scenario #1 – 11” Slab Thickness

Scenario #2 – 12” Slab Thickness



Scenario #11 – 17” Slab Thickness

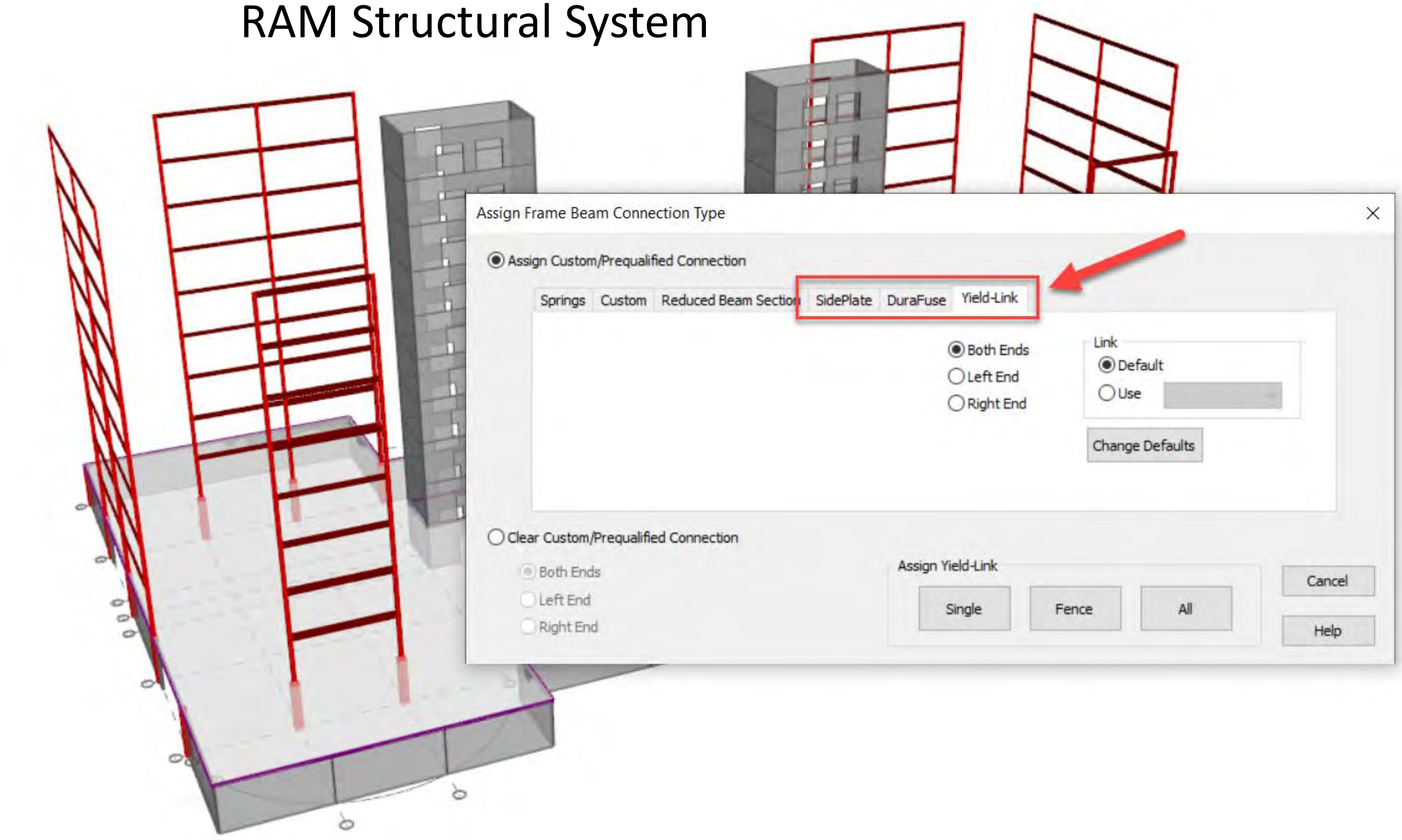




Source: London Energy Transformation Initiative, LETI Embodied Carbon Primer, January 2020.

Resiliency-Moment Connections

RAM Structural System



SidePlate

DuraFuse

Simpson Strong-Tie
Yield-Link

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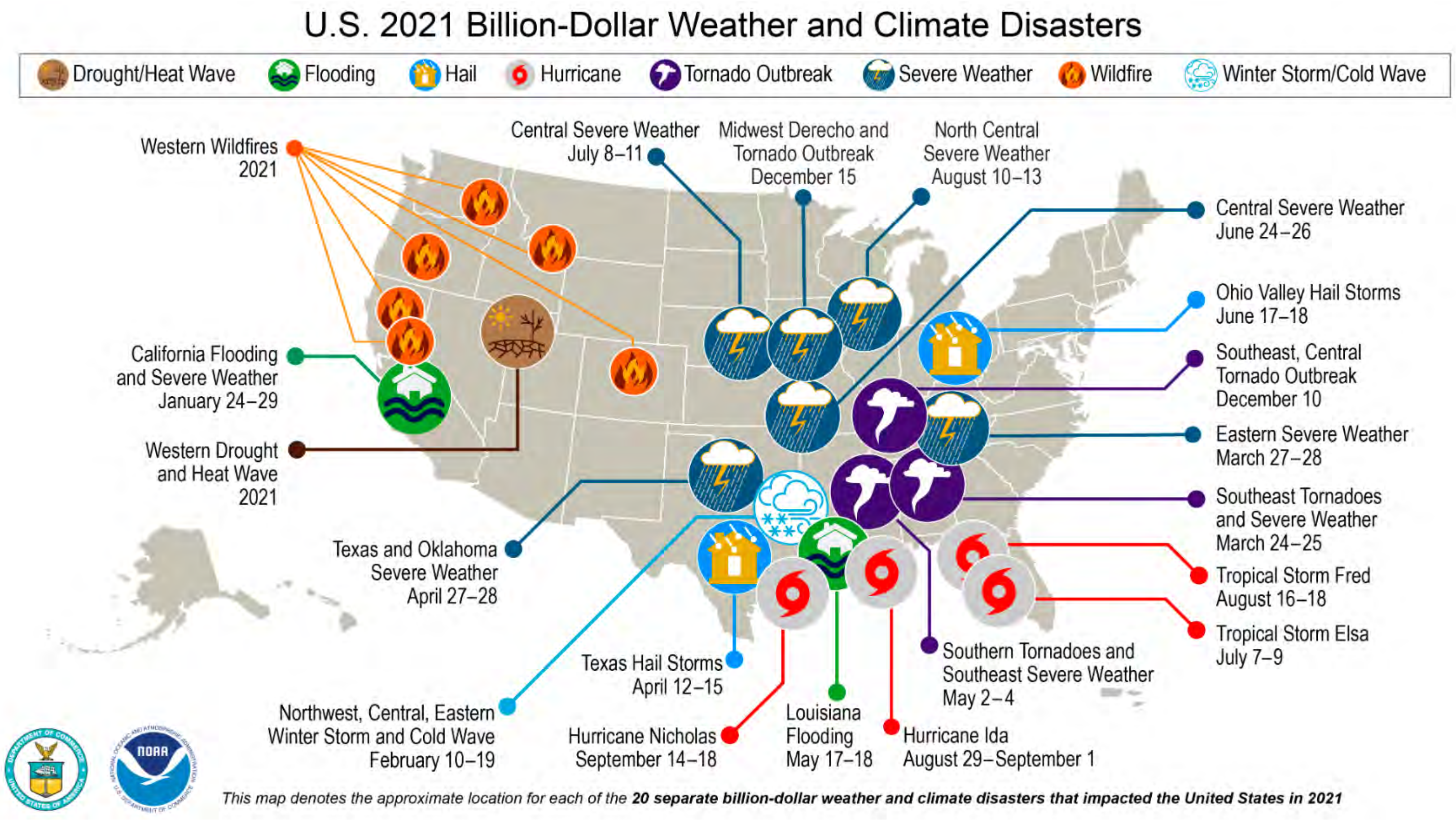
Source: DuraFuse Frames Technical Brochure

"Eight of the ten costliest natural catastrophes in US history have been wind related."

- US Resiliency Council



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CONTINUING EDUCATION AIA

Digital Twin – The Building Life Cycle

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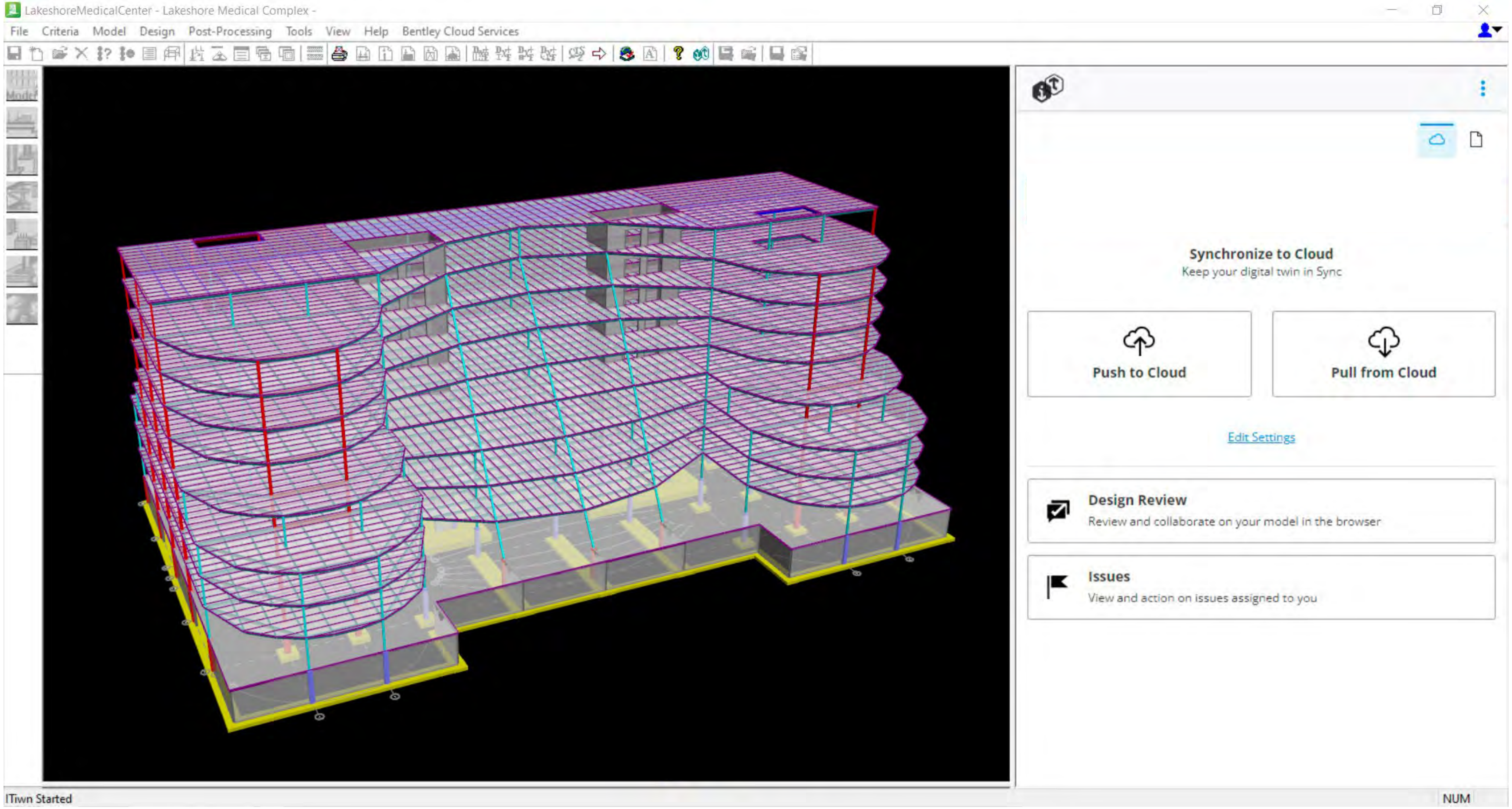
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File Criteria Model Design Post-Processing Tools View Help Bentley Cloud Services
Synchronize to Cloud
Keep your digital twin in Sync
Push to Cloud
Pull from Cloud
Edit Settings
Design Review
Review and collaborate on your model in the browser
Issues
View and action on issues assigned to you
ITwn Started
NUM

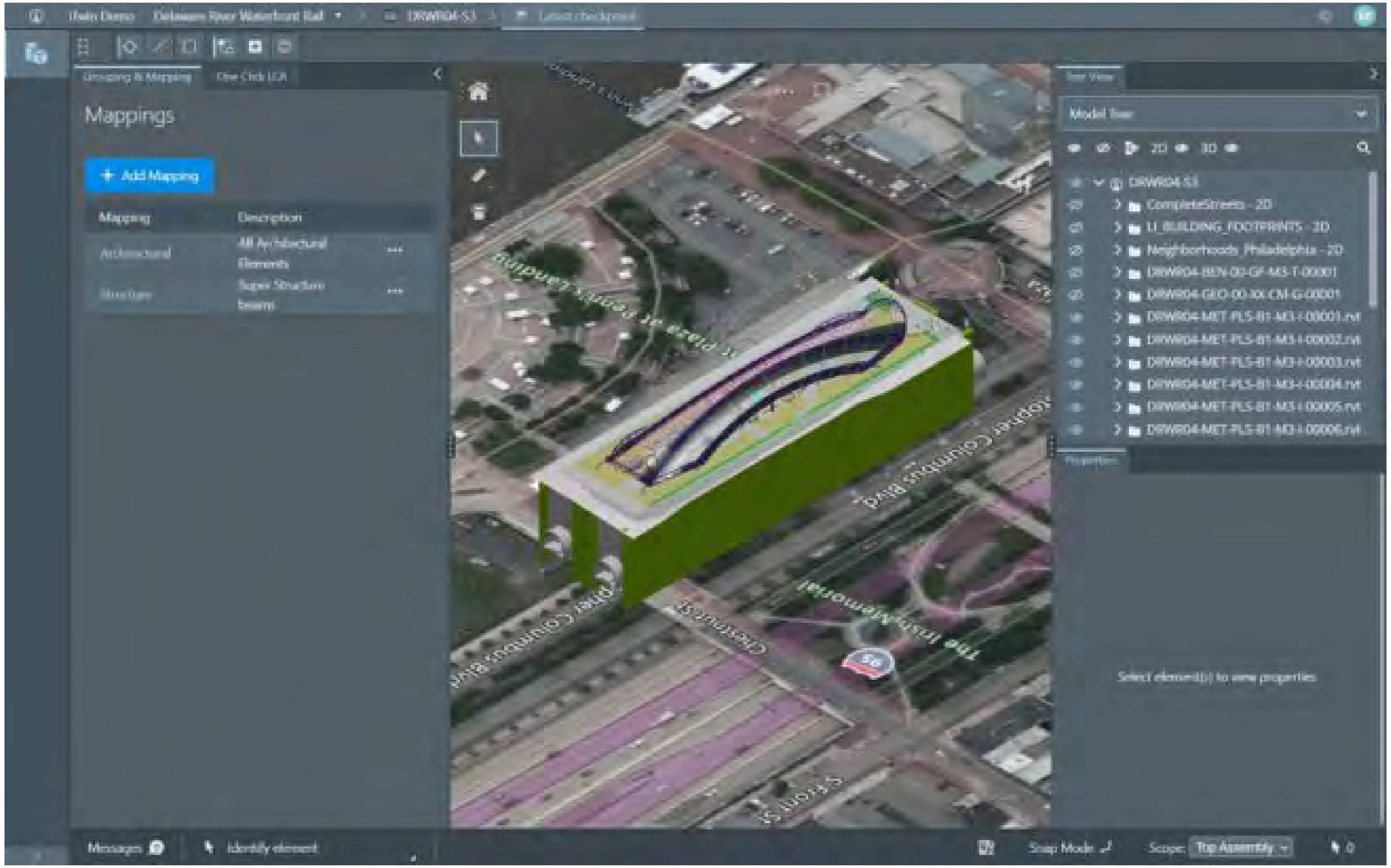
Carbon Accounting with iTwin Platform

LCA Report Generated in OneClick LCA

Data Exported from iModel

Bill of Quantities

iModel Design Data



Questions and Answers with:

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Seth Guthrie
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Todd Danielson
Editorial Director
Informed Infrastructure

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