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Practical Strategies for Embodied Carbon Reduction in Structural Design

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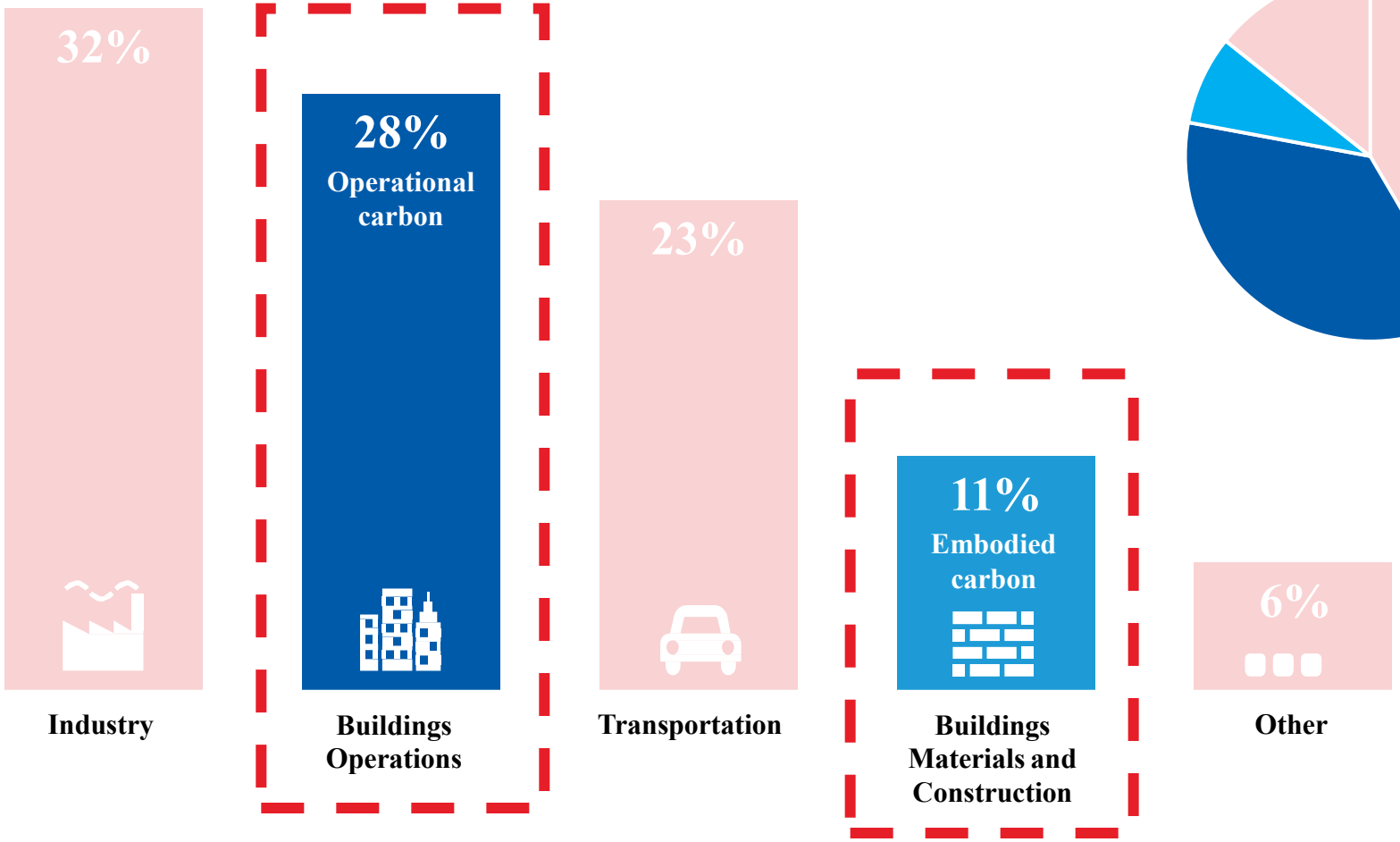
How Impactful is Embodied Carbon?



~39%

Construction sector carbon emissions

~6%

Emissions attributed to structures

World Green Building Council Global Status Report 2018

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Calculating Embodied Carbon

QUANTITY x **GWP FACTOR**

=

EMBODIED CARBON

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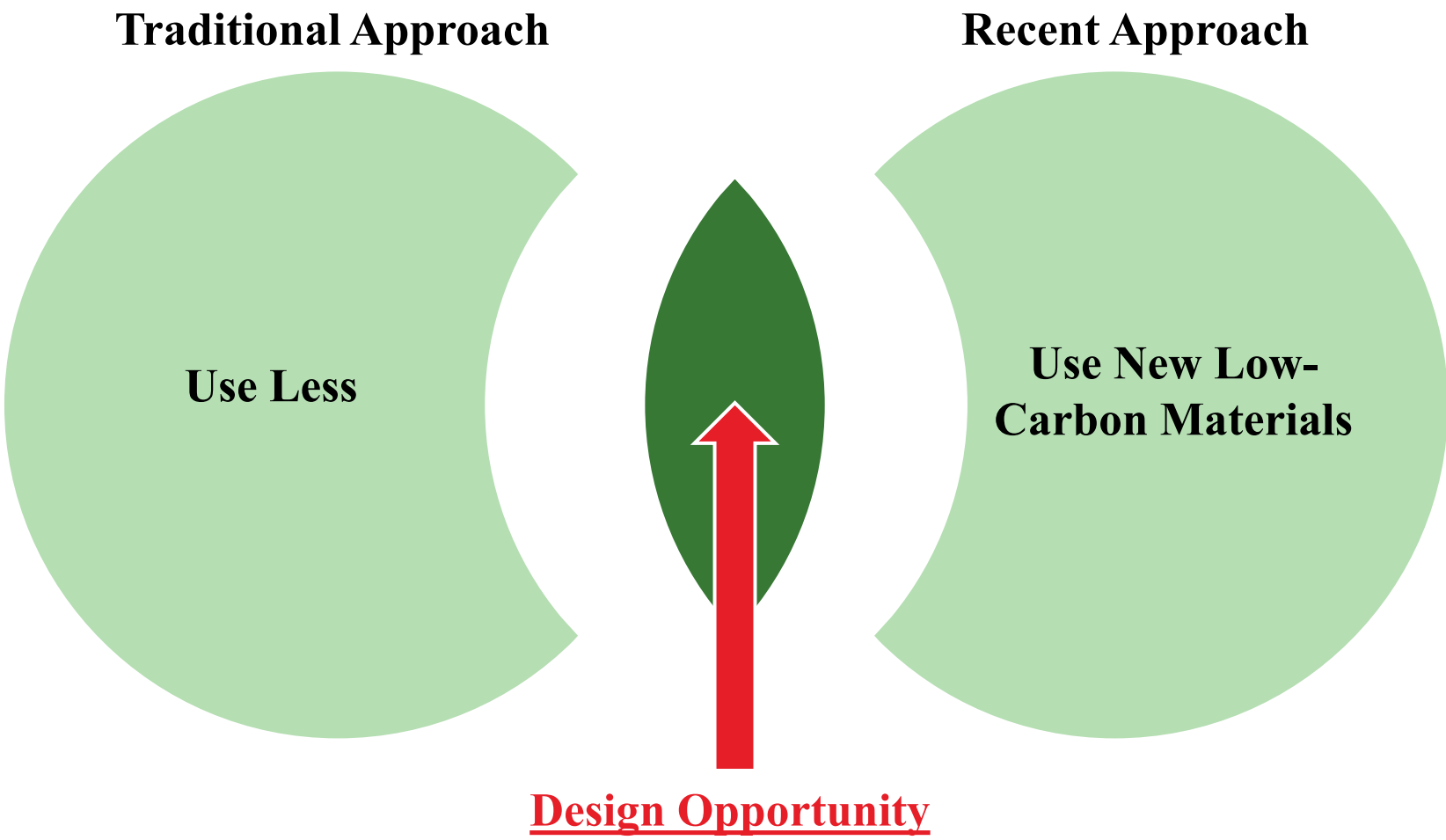
Reducing Embodied Carbon



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Use Normalweight Concrete In Lieu of Lightweight

- Lightweight concrete typically has an 80% carbon premium and 10% cost premium per cubic yard compared to normalweight concrete

Table E3-Great Lakes Midwest LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	192.43	211.66	252.63	304.40	321.68	380.19	401.57	445.91	489.97

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University of Michigan Case Study

Use of Normalweight Concrete Slab on Deck

- Project baseline scheme of CLT on steel framing
- Typical scheme of 3.25” LWC on 3” deck
- Alternate of 3” NWC on 3” deck

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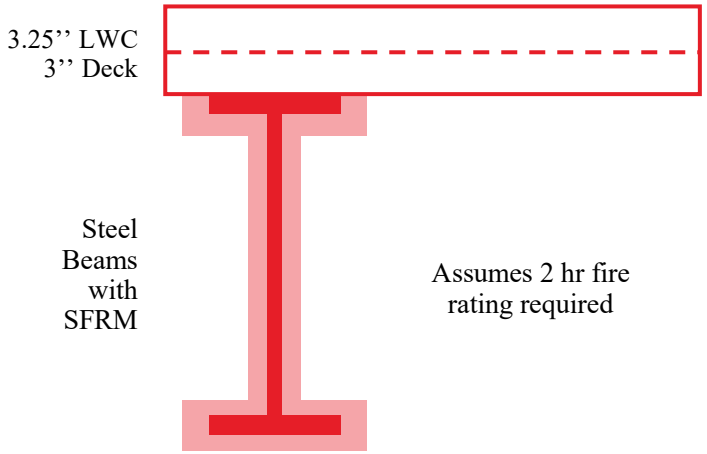
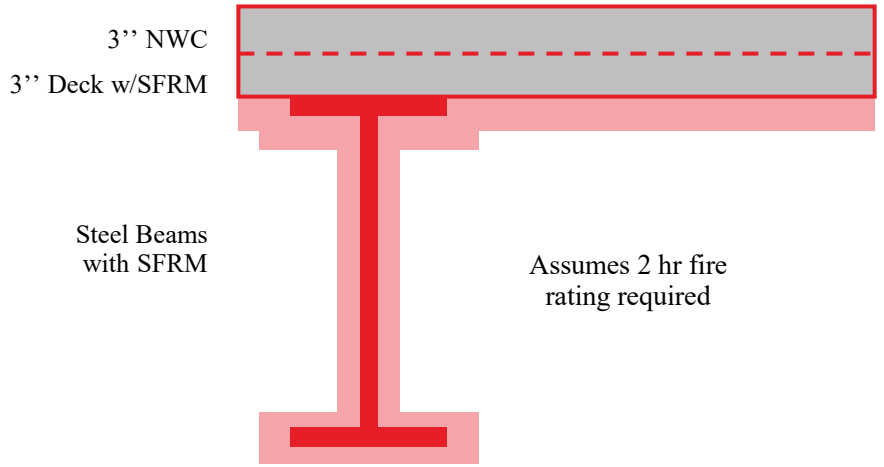
University of Michigan Case Study

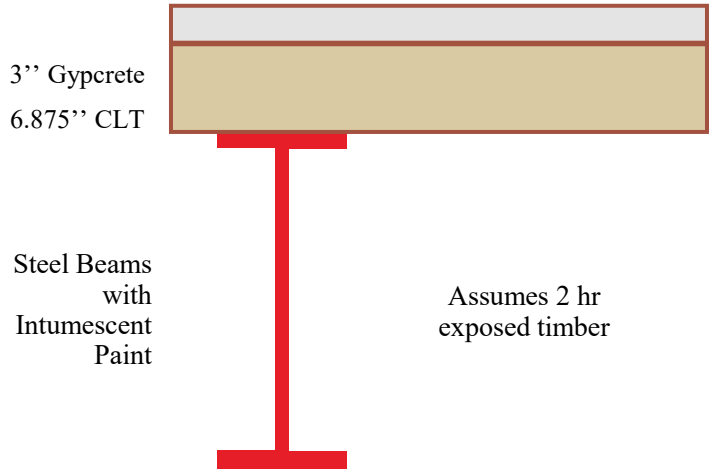
Use of Normalweight Concrete Slab on Metal Deck



Typical LWC + MD
~117kgCO_2e/m² (+33%)



NWC + MD
~92kgCO_2e/m² (+4.5%)



Baseline Scheme
~88kgCO_2e/m²

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Specify Low GWP Insulation

Insulation for Structural Applications

- **XPS** (Extruded Polystyrene)
  - Legacy XPS: Highest GWP by far due to HFCs
  - Low-GWP XPS available, related to recent state & federal regulations
- **EPS** (Expanded Polystyrene)
  - Significantly lower GWP (~13x) than legacy XPS, but not as durable
- **Polyiso**
  - Lowest GWP and similar durability as XPS
  - More expensive than alternatives

Material	Form or variant	R-value per inch	GWP average, kgCO2e per 1m² R_{SI}-1	GWP includes
Cellular glass	Aggregate	1.49	3.93	A1-A3, A5
Cellulose	Blown/loosefill, 1.29 pcf	3.38	-0.83	A1-A3, A5, carbon
Cellulose	Densepack, 3.55 pcf	3.56	-2.16	A1-A3, A5, carbon
Expanded polystyrene (EPS)	Board, unfaced Type IX-25psi, graphite	4.70	3.49	A1-A3, A5
Fiberglass	Batt, unfaced, recycled content	3.64	0.68	A1-A3, A5
Fiberglass	Blown/loosefill	2.68	1.30	A1-A3, A5
Fiberglass	Blown/spray	4.00	1.64	A1-A3, A5
HempCrete	Block	2.14	-5.67	A1-A3, A5, B1, carbon
Mineral wool	Batt, unfaced	4.24	3.25	A1-A3, A5
Mineral wool	Board, unfaced, "heavy" density	4.00	4.06	A1-A3, A5, B1
Phenolic foam	Board, glass tissue faced	7.21	1.54	A1-A3
Polyisocyanurate	Board, foil faced	6.53	2.32	A1-A3
Spray polyurethane foam	Spray, closed cell HFC	6.60	14.86	A1-A3, A5, B1
Spray polyurethane foam	Spray, closed cell HFO	6.60	4.00	A1-A3, A5, B1
Spray polyurethane foam	Spray, open cell	4.05	1.59	A1-A3, A5, B1
Straw	Panel	2.92	-10.88	A1-A3, A5, B1, carbon
Wood fiber	Board, unfaced	3.47	-7.13	A1-A3, carbon
Extruded polystyrene (XPS)	Board, 25psi HFC	5.00	46.51	A1-A3, A5, B1
Extruded polystyrene (XPS)	Board, 25psi HFO/HFC blend	5.00	8.83	A1-A3, A5, B1

https://www.greenbuildingadvisor.com/article/choosing-low-carbon-insulation

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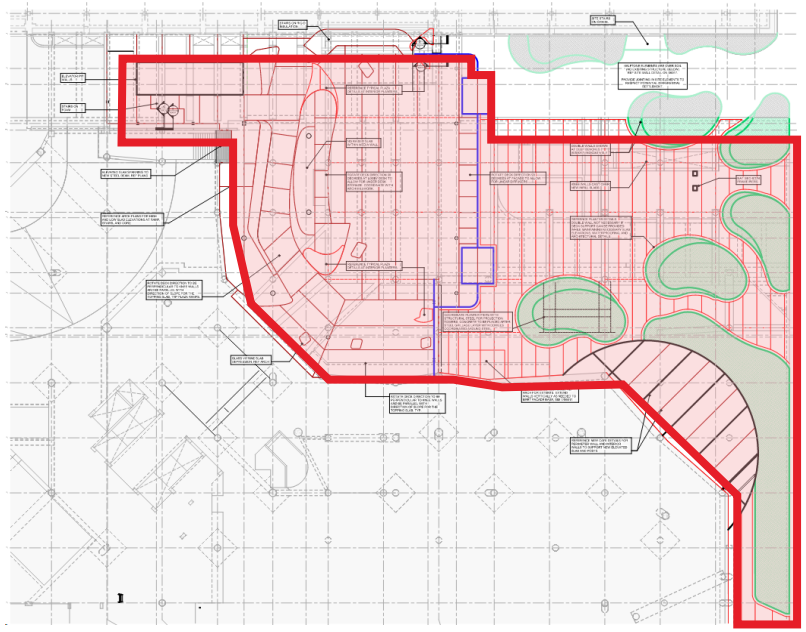
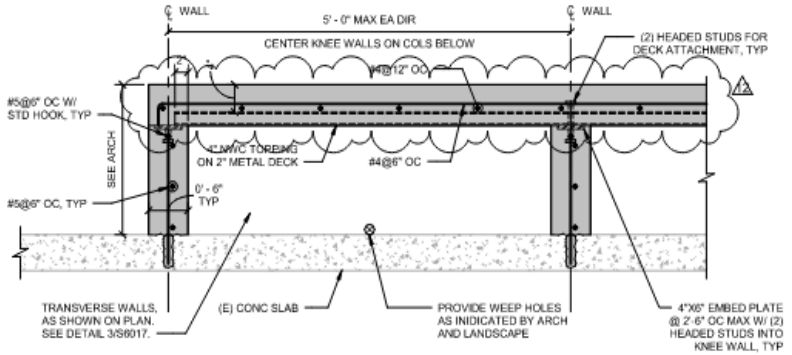
National Geographic Museum Case Study

Elimination of Insulation in Void Slabs at National Geographic





- Built-up slab on void former was replaced with slab on deck
- Revised detail eliminated 62,800 ft^3 of insulation and 7,850 ft^3 of concrete knee walls

Void Slab
Baseline 275T CO_2e
150T CO_2e Saved (↓ 45%)

Project (NWC + Void Slab)
Baseline 760T CO_2e
197T CO_2e Saved (↓ 26%)

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Arup Has the Expertise to Help You Achieve Carbon Reduction Goals

We built Zero to collect and analyze data about buildings' emissions across their lifespans

Since our commitment in 2021 we have assessed:

950+ Assets

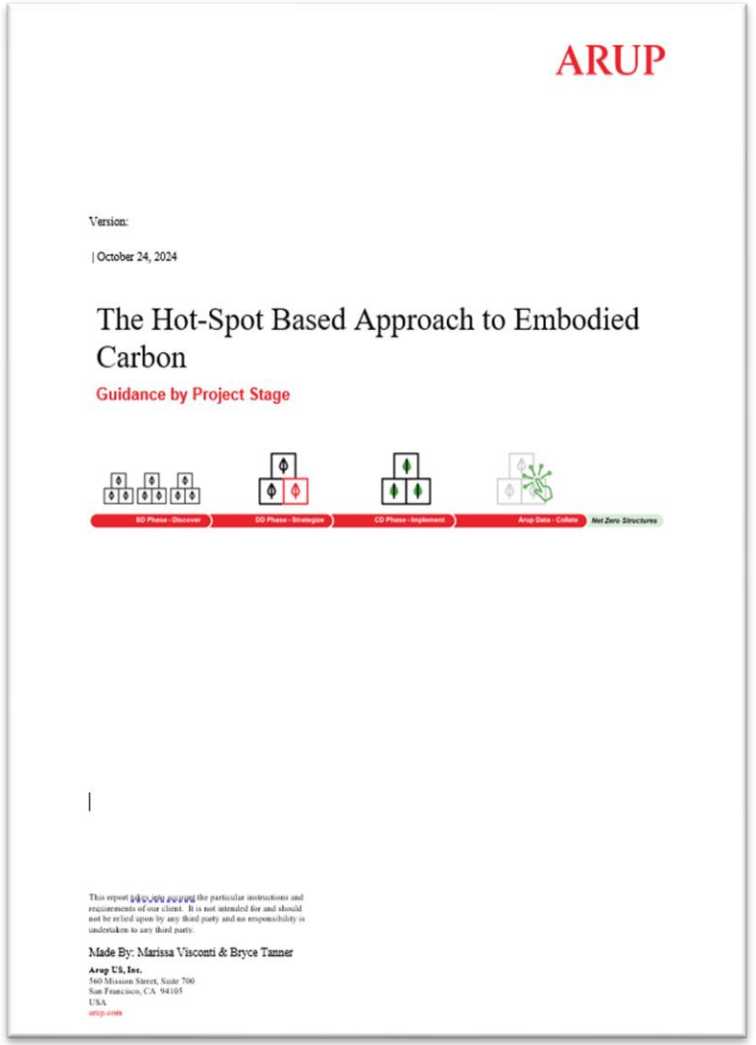
30 Countries

5 Continents

650m m² gross floor area

16 Building typologies

1100+ Arup engineers contributed data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Version:

| October 24, 2024

The Hot-Spot Based Approach to Embodied Carbon

Guidance by Project Stage

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