

# EMBODIED CARBON REDUCTION IN RESIDENTIAL STRUCTURES

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SIEGEL STRUCTURAL ENGINEERS

## LEARNING OBJECTIVES

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- What is embodied carbon?
- Distinction between embodied carbon and operational carbon
- Where does embodied carbon come from and why do we care?
- Production processes of two primary contributors of embodied carbon
- Strategies to reduce the embodied carbon for different materials

## INITIATIVES & COMMITMENTS

- AIA 2030 Commitment
- SE 2050 Commitment
- MEP 2040 Commitment

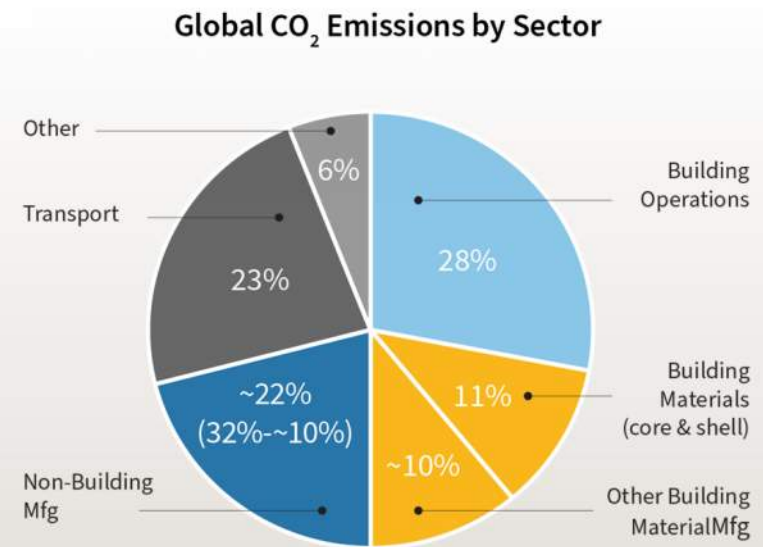


## EMBODIED CARBON VS OPERATIONAL CARBON



## WHERE DO EMISSIONS COME FROM?

- Built environment is responsible for approximately 50% of global carbon emissions
- Building and infrastructure materials and construction (typically referred to as embodied carbon) are responsible for  $\pm 13\%$  annually
- Three materials – concrete, steel and aluminum are responsible for  $\pm 23\%$  of total global, most of it used in built environment



Adapted from 2019 Global Status Report, Global Alliance for Building and Construction (GABC) and Architecture 2030.

## WHERE DO EMISSIONS COME FROM?

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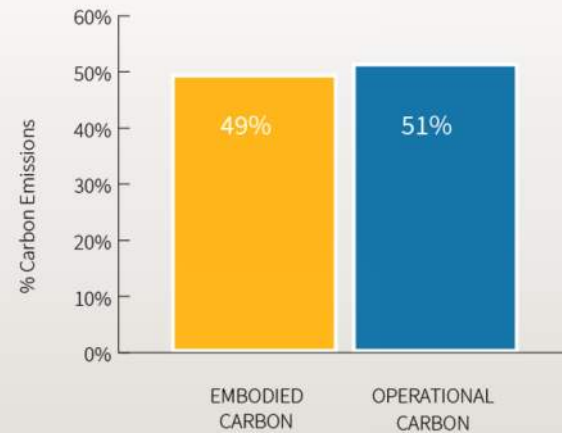
By 2060, the world is projected to add 230 billion m<sup>2</sup> (2.5 trillion ft<sup>2</sup>) of buildings, or an equal to the entire current global building stock\*. This is the equivalent of adding an entire New York City to the planet every month for the next 40 years.

\*UN Environment, Global Status Report 2017

## WHY DO WE CARE?

- Operational carbon can be reduced with building energy efficiency projects.
- Embodied carbon emissions are locked in place as soon as the building is built.
- Emissions released now are more critical than emissions released later.

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



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# HOW TO MEASURE EMBODIED CARBON?

- Global warming potential (GWP) measured as kg/m<sup>3</sup>
- Environmental Product Declarations (EPD)
- $GWP \times \text{Material Volume} = \text{Total GWP}$



This Environmental Product Declaration (EPD) reports the impacts for 1 m<sup>3</sup> of ready mixed concrete mix, meeting the following specifications:

- ASTM C94: Ready-Mixed Concrete
- UNSPSC Code 30111505: Ready Mix Concrete
- CSA A23.1/A23.2: Concrete Materials and Methods of Concrete Construction
- CSI Division 03-30-00: Cast-in-Place Concrete

**COMPANY**

Aggregate Industries  
8700 Bryn Mawr Ave Suite #300  
Chicago, IL 60631-3512



**ENVIRONMENTAL IMPACTS**

**Declared Product:**

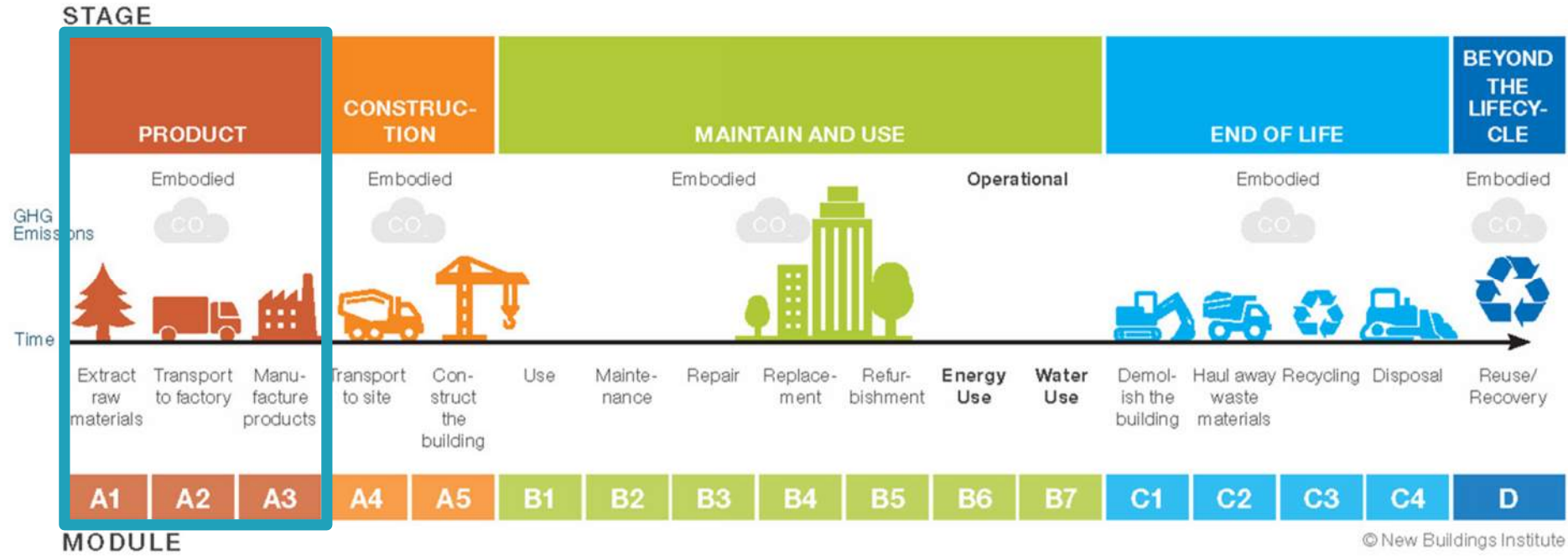
Mix 408303 • Waltham Plant  
Description: 4000 3/8" NAE MRWR with 20% Fly Ash  
Compressive strength: 4000 PSI at 28 days

**Declared Unit:** 1 m<sup>3</sup> of concrete

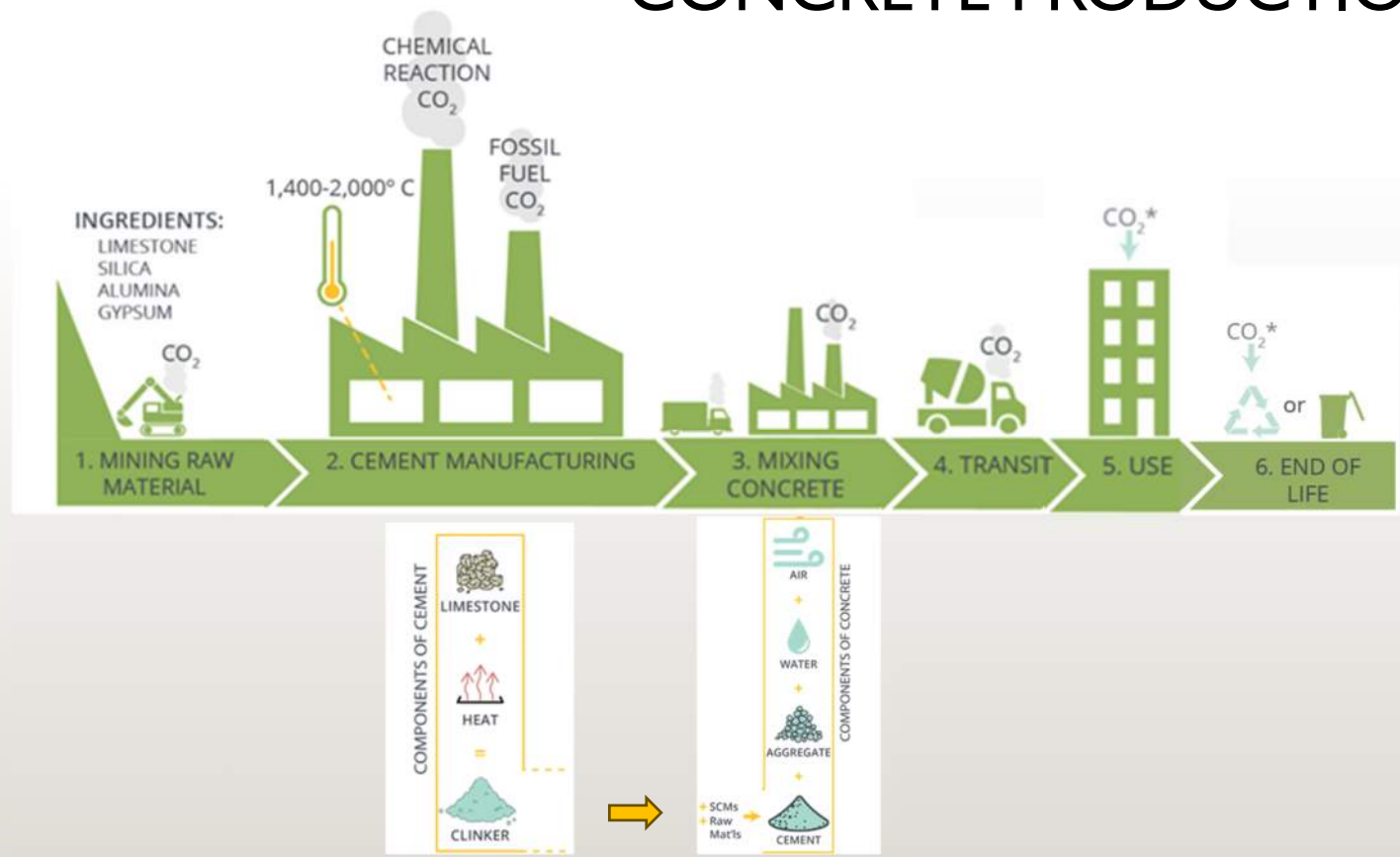
Global Warming Potential (kg CO <sub>2</sub> -eq)	339
Ozone Depletion Potential (kg CFC-11-eq)	8.03E-6
Acidification Potential (kg SO <sub>2</sub> -eq)	0.97
Eutrophication Potential (kg N-eq)	0.38
Photochemical Ozone Creation Potential (kg O <sub>3</sub> -eq)	0.14



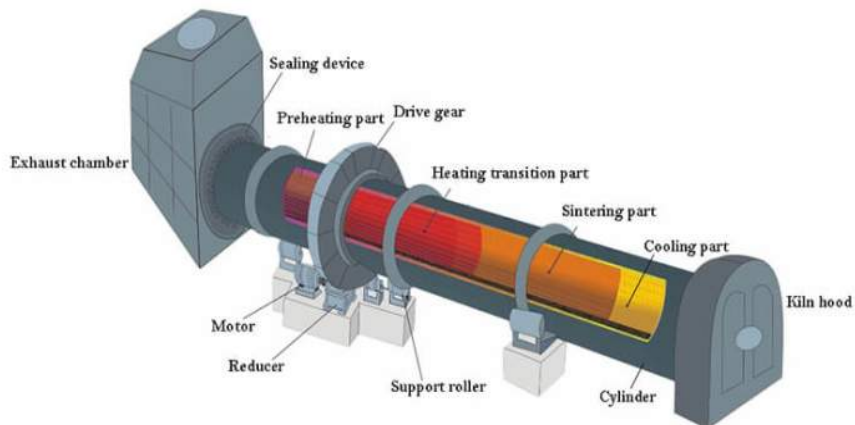
# LIFE CYCLE ANALYSIS



# CONCRETE PRODUCTION



# CONCRETE PRODUCTION



ROTARY CEMENT FURNACE/KILN DIAGRAM

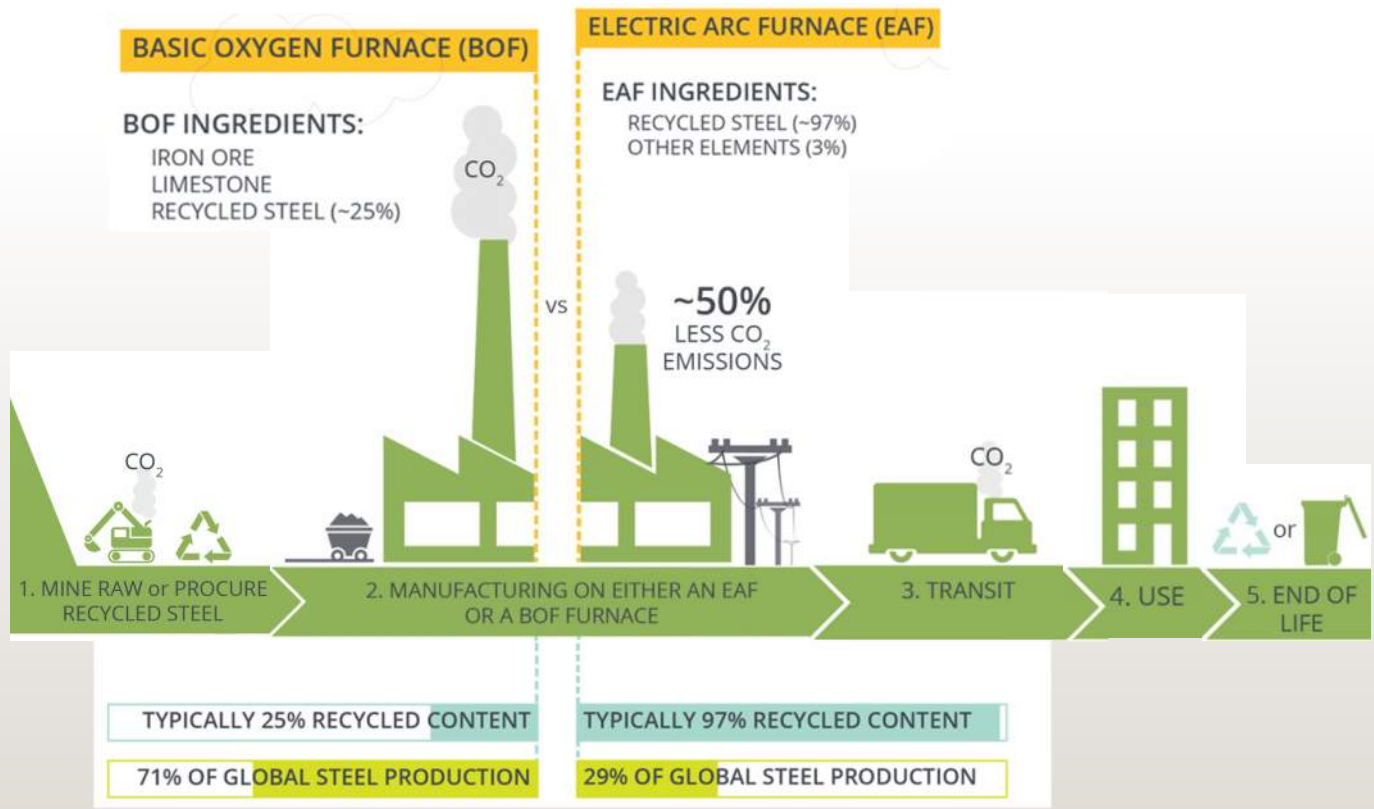
SOURCE: AGICO CEMENT



ROTARY CEMENT FURNACE/KILN

SOURCE: TAIHEIYO CEMENT

# STEEL PRODUCTION



## STEEL PRODUCTION



ELECTRIC ARC FURNACE

SOURCE: GRECIAN MAGNESITE



## WHAT CAN WE DO?

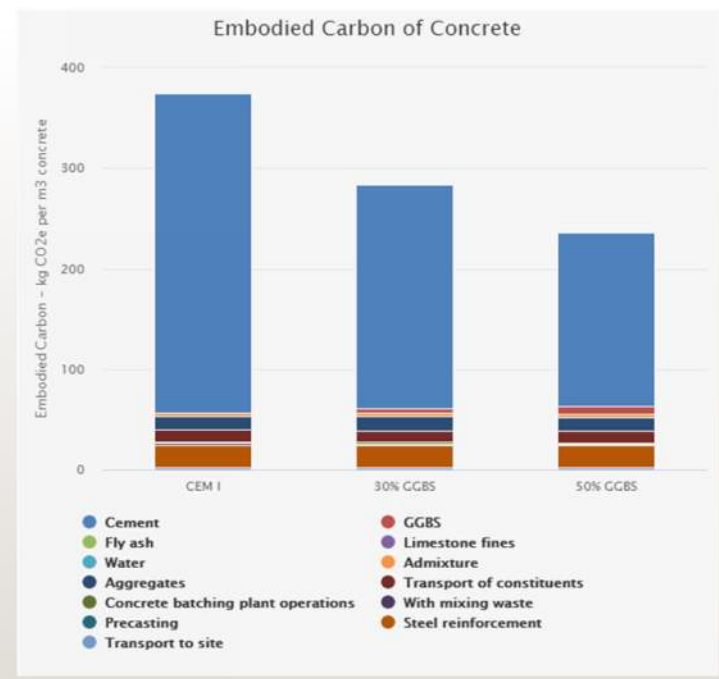
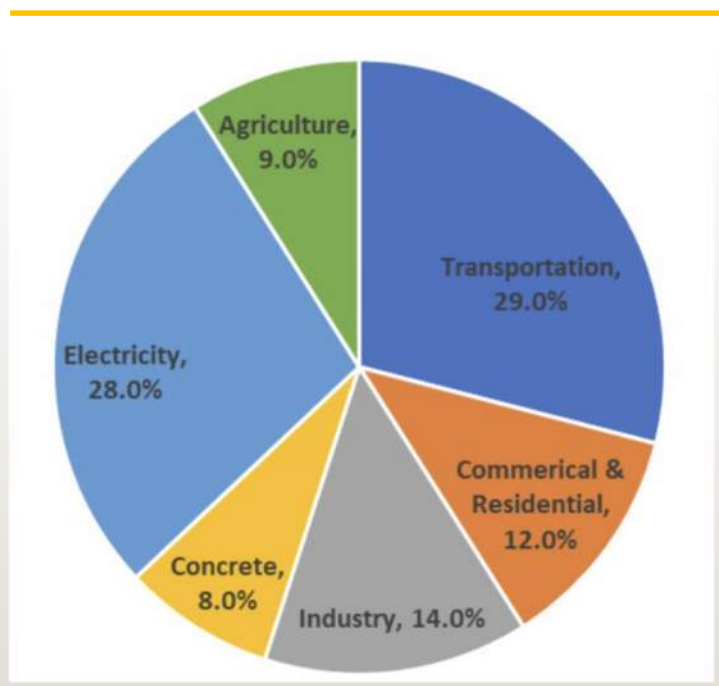
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- Concrete
- Steel
- Wood
- Reuse!
- Raise awareness

# CONCRETE

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## WHY FOCUS ON CONCRETE?





## HOW TO REDUCE CONCRETE?

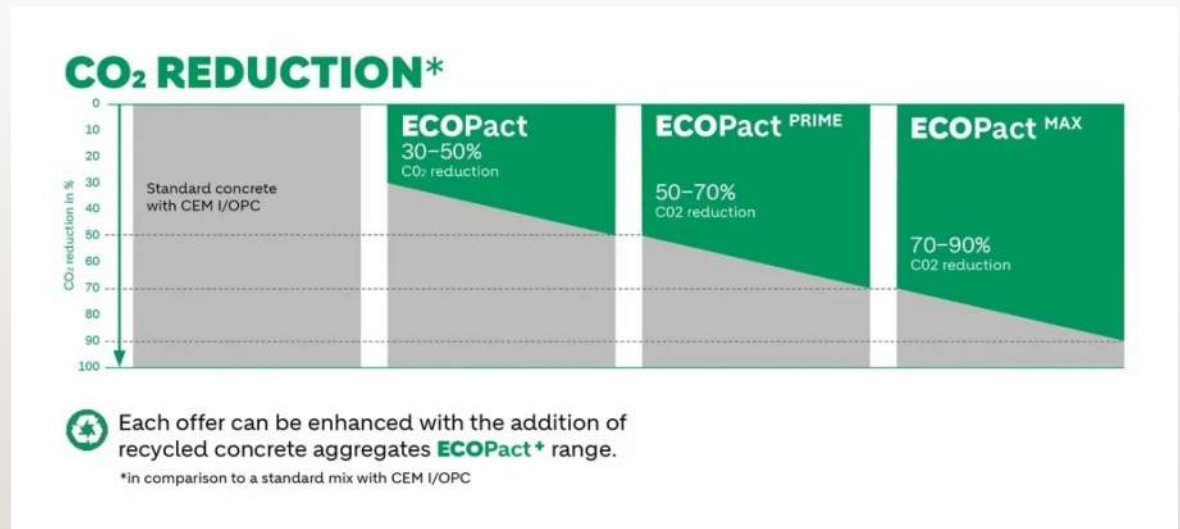
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ZERO/ NEGATIVE CARBON CONCRETE IS COMING



## HOW TO REDUCE CONCRETE?

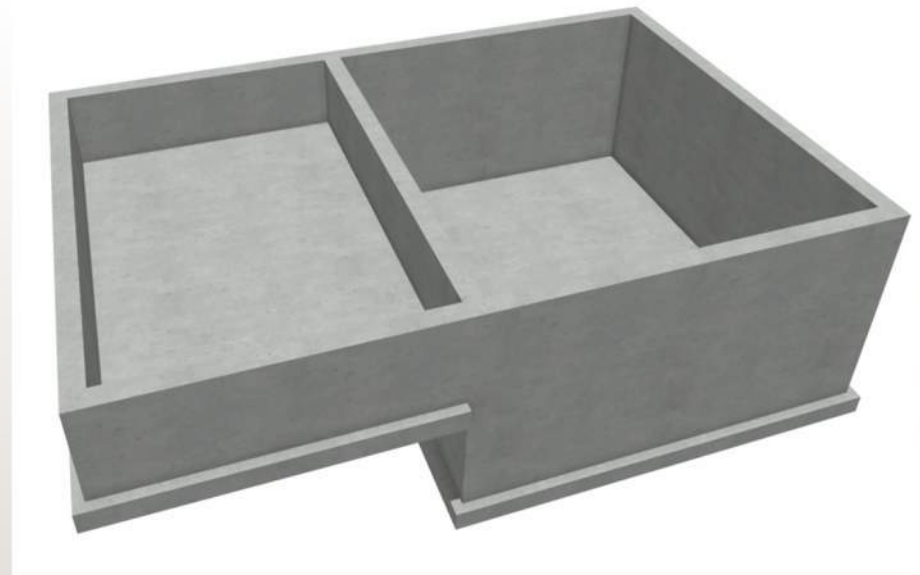
- ECOPact concrete by Aggregate Industries
- Offers 30%-50% reduction in GWP for ~10% cost premium



## REDUCE VOLUME

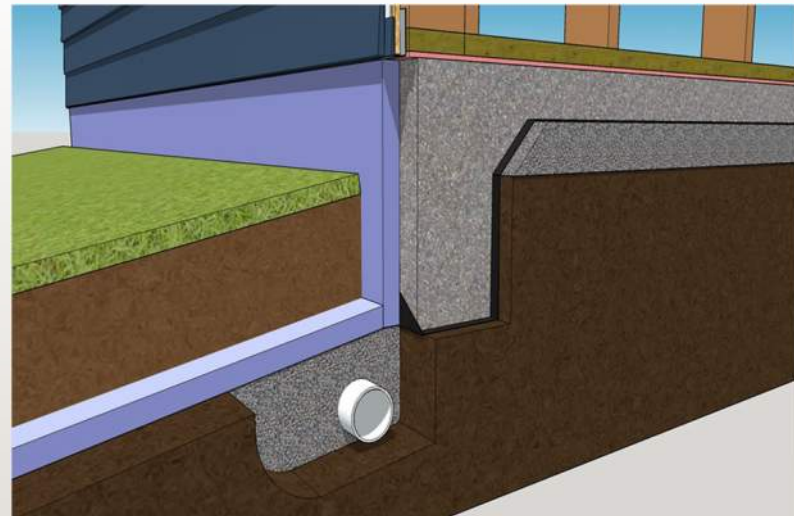
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- How: Crawl space instead of full basement
- Solution:  $\pm 30\%$  reduction in GWP due to concrete



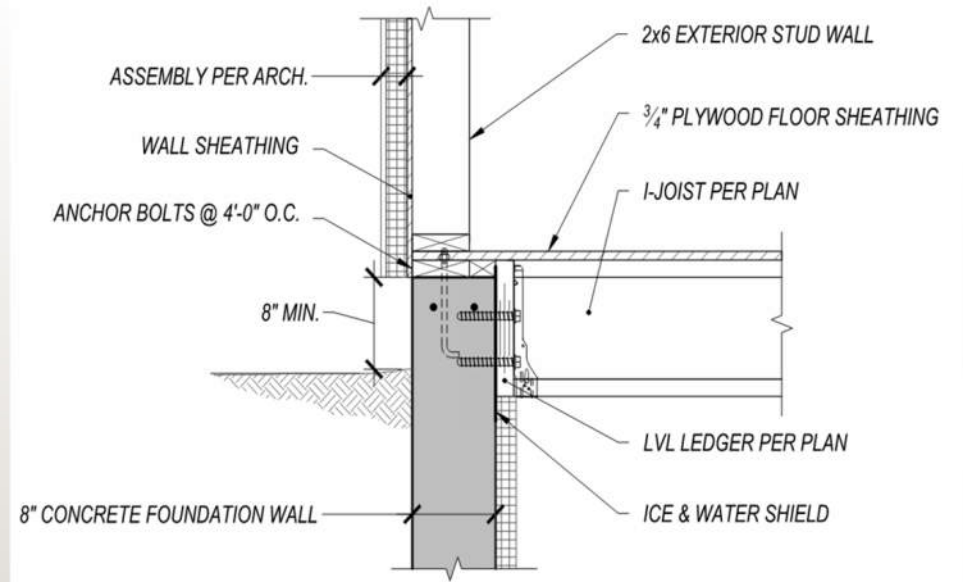
## REDUCE VOLUME

- Shallow frost-protected foundations



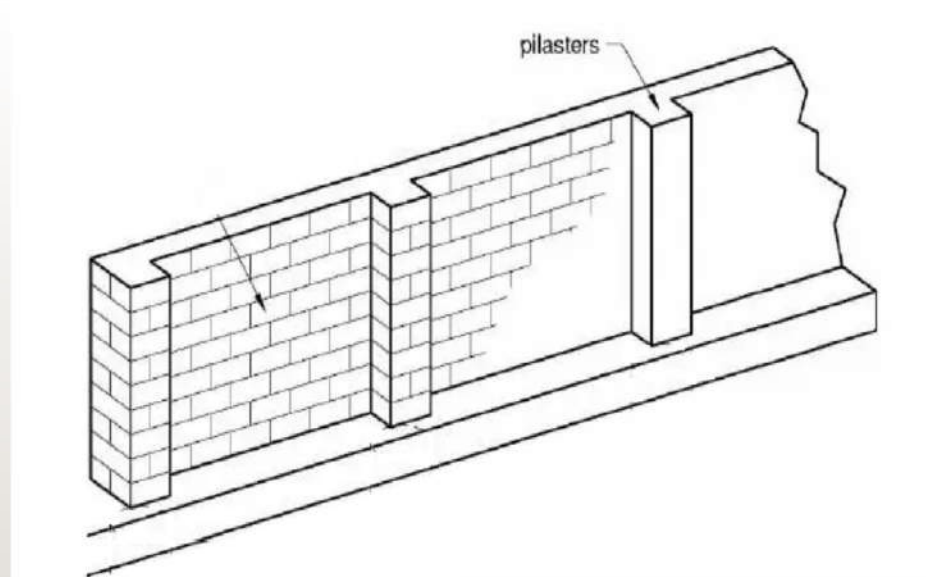
## REDUCE VOLUME

- 8" foundation walls



## REDUCE VOLUME

- 8" foundation walls
  - Pilasters often required at large HDU locations
  - Thinner walls require more precise rebar placement



## REDUCE VOLUME

### Precast Concrete Foundation Walls

- Superior Walls
  - Better Insulation
  - Transportation and Material Efficiency
  - Quick installation results in lower labor costs



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## REDUCE VOLUME

### INSULATED CONCRETE FORMS (ICFs)

- Reduced Volume
- Embedded plastic webs for accurate rebar placement
- Faster installation
- Acoustics resulting in quiet space
- Finishes can be attached to the face directly.

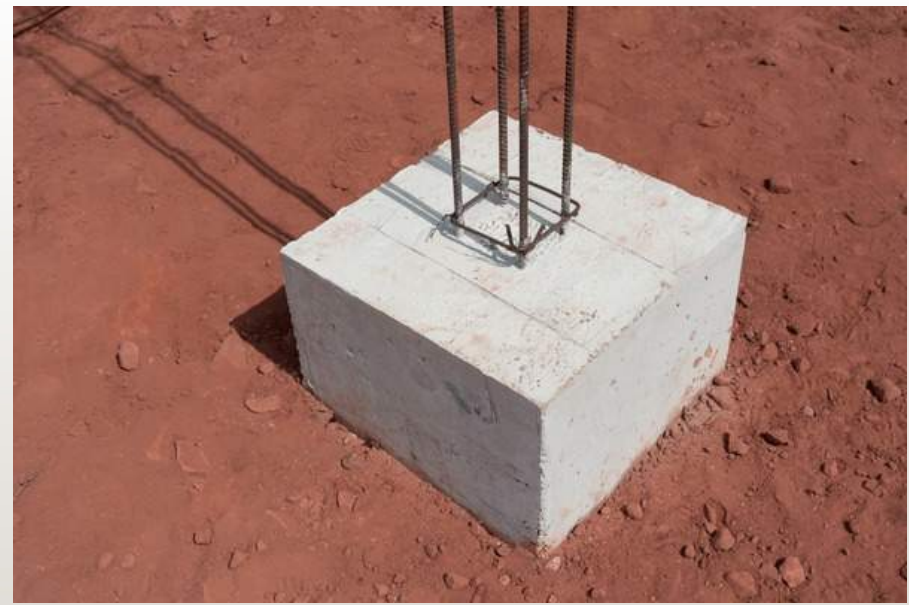
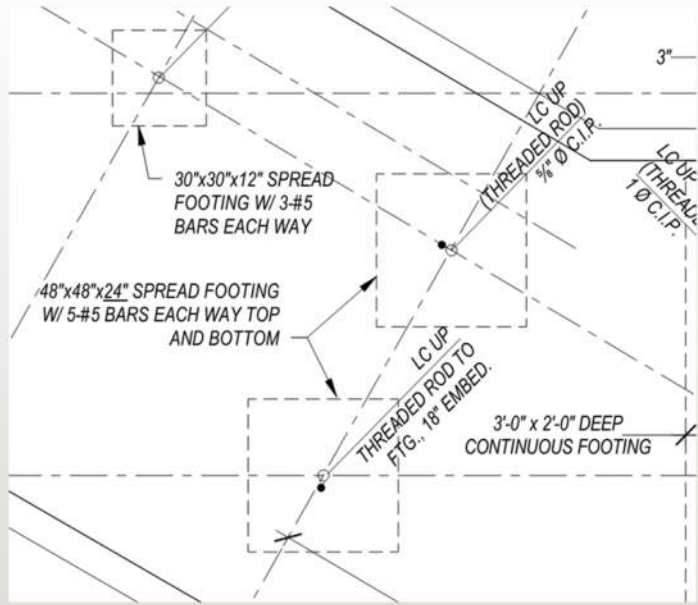


## REDUCE VOLUME



# REDUCE VOLUME

Use Helical Piles or Micropiles



## REDUCE VOLUME

Use micropiles in lieu of concrete pier with belled footings



# STEEL

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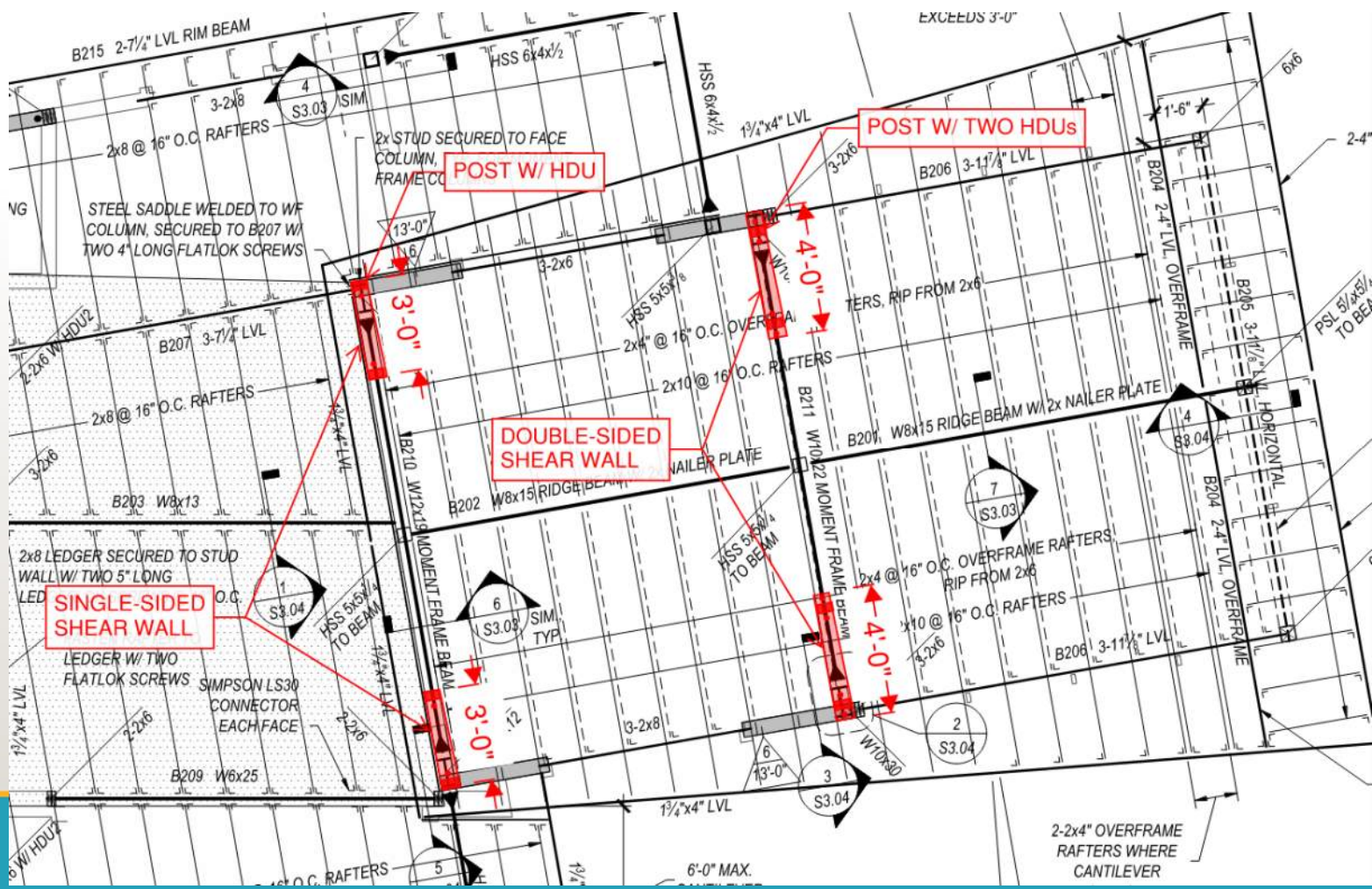
## SOURCING

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- Steel plants operating on renewable energy
- Source from suppliers that reuse
- Talk to steel suppliers about low carbon options



# REDUCE VOLUME



SAMPLE PROJECT ONLY; CONSULT AN ENGINEER FOR YOUR SPECIFIC APPLICATION

## REDUCE VOLUME

### Simpson Strong-Wall Shearwall System

- Lateral Load Resistance
- Efficient Installation
- Cost-Effective





## REDUCE VOLUME

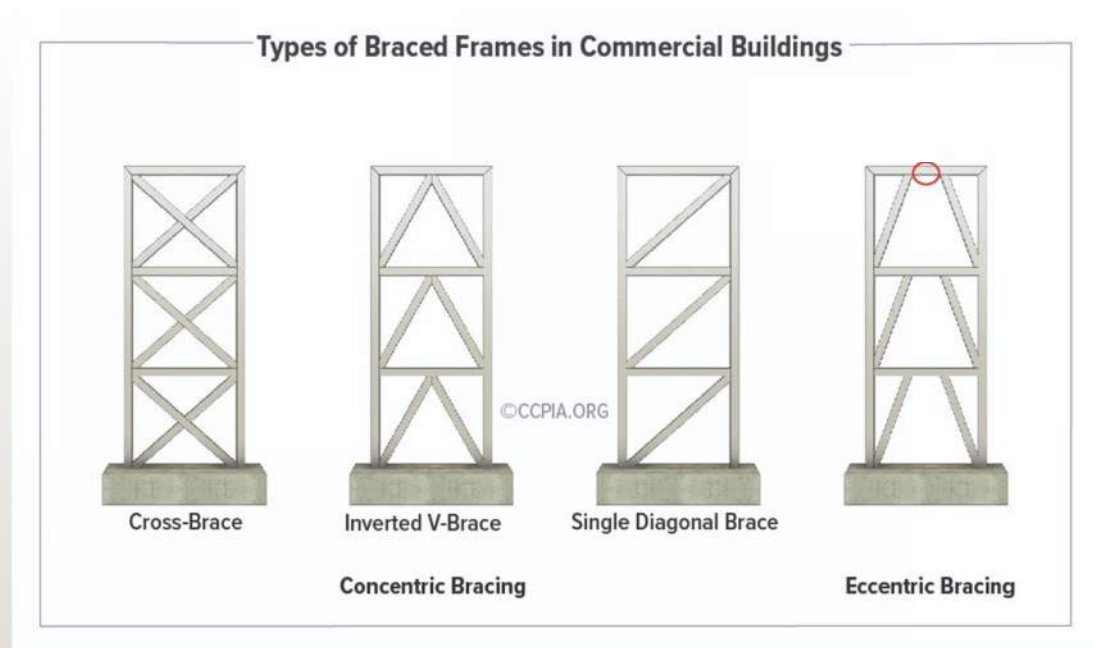
### Simpson Strong-Wall Shearwall System

- Lateral Load Resistance
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## REDUCE VOLUME

- Braced frames instead of moment frames



## WOOD (IS GOOD)

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## WOOD (IS GOOD)



## IN PLACE OF STEEL

- Deep LVL or Glulam members
- Strategically-placed posts
- Reclaimed timber for new projects



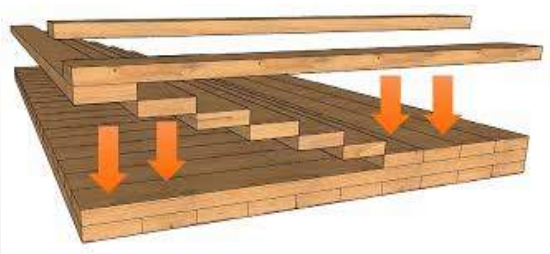
## IN PLACE OF STEEL

- Deep LVL or Glulam members
- Strategically-placed posts
- Reclaimed timber for new projects



## IN PLACE OF STEEL

- CROSS LAMINATED TIMBER (CLTs)



# REUSE

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## REUSE

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**“Far and away the best way to reduce carbon is to re-use existing buildings. By recycling structure, we can save up to 40% of emissions. These targets are achievable now.”**

—Juliette Morgan, Head of Sustainable Development, British Land

## REUSE

Reusing existing structures offers several advantages over building new ones:

- Sustainability and less environmental impacts
- Cost effectiveness
- Time Savings



Source: ThinkWood

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## AWARENESS: WHAT CAN WE DO TOGETHER?

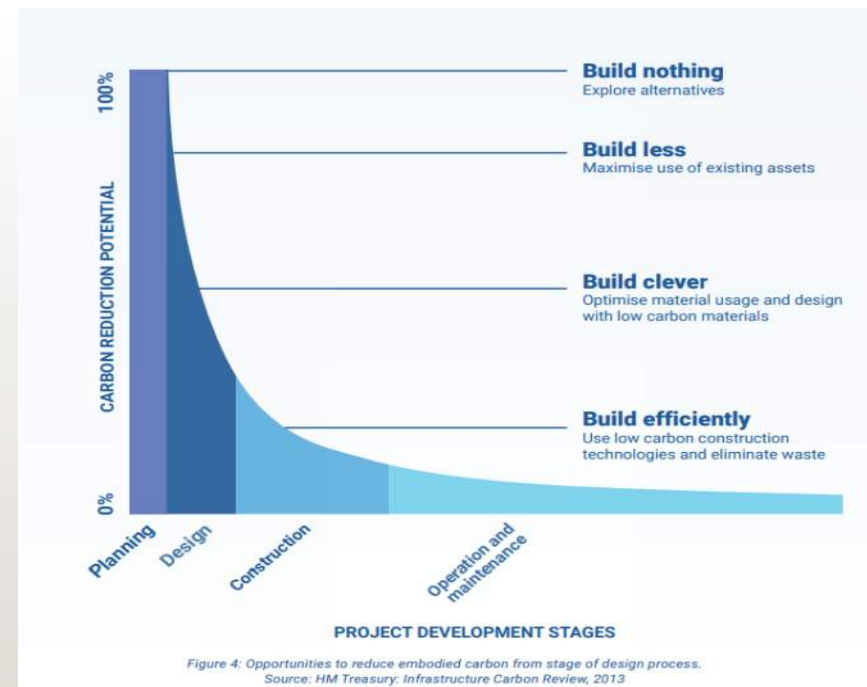
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- Educate our teams, clients, developers, builders
- Create compelling stories for clients that encourage them to make an impact with their material choices
- Provide alternative materials
- Ask industry manufacturers to produce EPD

## CARBON REDUCTION POTENTIAL

The largest carbon reduction potential can usually be realized at the earliest stages of a project.

SOURCE: WORLD GREEN BUILDING COUNCIL



## IN CONCLUSION

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- Whole team cooperation right from the start
- Collaboration with industry partners
- Engaging design professionals in the planning stage

QUESTIONS?

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