Climate Conscious Building Design

Donald Davies, P.E., S.E. - Principal
Where the US Building Industry Has Been
MKA Culture - Optimized Structures

Structural Steel Weight vs. Number of Stories

Legend
- Deep hole MWA
- Deep hole Others
- Actual structural steel
- Structural steel with concrete
- Structural steel with concrete and steel
- Structural steel based on cost

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Bio-mimicry
Multi-Purpose Solutions
Where the Industry Is Heading
Green Building
International awareness
Momentum to lower climate impacts
First we must answer the question, “Where Are We?”
Life-Cycle Analysis

Phase I (Embodied) Carbon
Phase II (Operating) Carbon
Phase III (Deconstruction) Carbon

Source: SB Alliance, 2009
A Building’s Life-Cycle Carbon

- Phase 1P – Embodied
- Phase 2P – Operations
- Phase 3P – Deconstruction

Carbon Content (1000 tons) vs. Years

MEASURABLE
PREDICTION
Changes with time

Current Life Cycle Carbon

Future Life Cycle Carbon
Phase I - Embodied Carbon Modeling

- Structure 28%
- Envelope 20%
- Systems 18%
- Finishes 20%
- Site Work 7%
- Construction 7%
A Different Take on Embodied Carbon

50% Structural reduction = 6 years operating carbon

Operating Carbon Over 30 Years
Embodied Carbon Calculators

Estimate the embodied CO₂ of a whole construction project.

The Construction Carbon Calculator helps developers, builders, architects and land planners approximate the net embodied carbon of a project's structures and site.

1: reduce  2: renew  3: offset

Constructing new buildings and sites with the least possible environmental impact involves three important steps: reduce, renew and offset. Offsetting means calculating the project's carbon footprint so it can be balanced by funding resources or activities like renewable energy and land protection — resources that benefit and protect the planet.

This tool estimates the embodied energy and subsequent carbon amounts released during construction. The measurements account for building materials, processes and carbon released due to ecosystem degradation or sequestered through landscape installation or restoration.

Learn more about this calculator: why it exists, how it works and why you should use it!

Construction Carbon Calculator

Building Size
Total Square Feet: 100000
Stories Above Ground: 3
Stories Below Ground: 2

Primary Structural System Above Ground
- Wood
- Concrete
- Steel
- MAbec

Site
Ecoregion: (view map)
- Marine west coastal forest

Predominant Existing Vegetation:
- Previously Developed

Predominant Installed Vegetation:
- Shrubland

Landscape (SF)
Disturbed: 43560
Installed: 20000

I have read and agree to the terms of use.
Calculate

reduce & renew | calculate | offset | about the calculator | assumptions | faq | send feedback
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How to count the Carbon?

Desired Results

Economic Input / Output

Material Components
Hybrid Model
Hybrid Model Case Study
Hybrid Model

- Aluminum Windows (50% aluminum, 50% glass)
- Drywall (5% paper, 95% gypsum)
- Iron And Steel Forgings
- Ready Mixed Concrete
- Brick And Structural Clay Tile
- Plumbing Fixture Fittings And Trim
- Electrical Machinery Equipment And Supplies N E C
- Heating Equipment Except Electric And Warm Air Furnaces
- Elevators And Moving Stairways
- Doors, Frames, Hardware (Webcor)
- Wood Kitchen Cabinets
- Paints And Allied Products
- Miscellaneous Plastics Products N E C
- 50% plastic, 50% steel
- Household Appliances N E C
- Industrial And Commercial Machinery And Equipment N E C
- Glass And Glass Products Except Containers
- Everything Else
MKA ‘C’ Tool
– Structural Material/Product Modeling
BIM Model – Material Quantities Defined
Material Sourcing – Require a Pedigree

- **Concrete Supply Chain**
- **Steel Supply Chain**

Source: Cemex
Tracking the Energy Supply
Energy - #CO2/MWh – Select US Regions

Data from CARMA (www.CARMA.org)
Energy - #C02/MWh – Select Int’l Regions

Data from CARMA (www.CARMA.org)
Seattle Hotel - Case Study
Concrete Structure – CO₂

Drywall “Dropped” Ceiling

Rendered Concrete Ceiling

EXTERIOR WALL

INTERIOR WALL

Concrete Structure - CO₂

- Concrete
- Rebar
- Formwork
- Cold Formed
- Drywall
- PT
Complementary Cementing Materials (CCM)

Cement replacement by 10-100% with coal fly ash, slag, rice husk ash, or oyster shell powder
iCrete Technology

Sorting Control of Aggregate Matrix – PBD mixes:
Reduce Cement by 20-30% +

Standard Mix Design  iCrete Mix Designs
iCrete Technology

Design Mix
- Typical
- iCrete

Typical icrete Design Mix

$f'_c$ Design

$f'_c$ Target = Typical

$2\delta$

5%
iCrete Technology

Design Mix

- Typical
- iCrete

$f'_c$ Design

$f'_c$ Target = iCrete

$f'_c$ Target = Typical

Cement Savings

2σ

5% 5%
Sustainable Concrete
Competition 2010

Setting concrete foundations for the future.
“Bubble Deck”
Variable Steel Grade

60 ksi
75 ksi
90 ksi
120 ksi

$/ton
carbon/ton
Thermal Mass – Myth and Reality
Case Study Possible Savings?

**Embodied Carbon of Alternative Structural Systems: Seattle Hotel Project**

<table>
<thead>
<tr>
<th>Structural Alternative</th>
<th>CO₂ (avg. ptf per floor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>50</td>
</tr>
<tr>
<td>Steel</td>
<td>38</td>
</tr>
<tr>
<td>Carbon-optimized</td>
<td>20</td>
</tr>
</tbody>
</table>

- 22% reduction for Structural Alternative 1
- 43% reduction for Structural Alternative 3
- 49% reduction for Structural Alternative 4
- 23% reduction for Structural Alternative 5
- 35% reduction for Structural Alternative 6
- 47% reduction for Structural Alternative 7
- 53% reduction for Structural Alternative 8

Legend:
- **Concrete**
- **Steel**
- **Carbon-Optimized**
Case Study Possible Savings?

- Baseline
  - 5000 ton bldg
- 50% Reduction
  - 2500 tons saved
2500 Tons of Carbon =

- 6 years of operating carbon
- Yearly average use of 415 cars
- 1666 car trips from Seattle to New York
- 2500 flights from Seattle to New York