TRACKING CARBON THROUGH DESIGN: FROM EARLY-STAGE CARBON ACCOUNTING TO WHOLE BUILDING LIFE CYCLE ASSESSMENT

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Team Carbon Unit Director & Structural Engineer afeitel@klaa.com

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.
MEASURE, REPORT, AND REDUCE: USING COMPARATIVE LCA TO HIGHLIGHT THE EMBODIED CARBON BENEFITS OF WOOD CONSTRUCTION

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• PLATTE FIFTEEN LCA CASE STUDY
• RETURN TO FORM LCA CASE STUDY
• CONCEPTUAL DESIGN EMBODIED CARBON QUANTIFICATION
### Life Cycle Stages & Study Scope

<table>
<thead>
<tr>
<th>Product</th>
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<th>Use</th>
<th>End-of-Life</th>
<th>Module D</th>
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Figure 3. Life Cycle Stages as defined by EN 15978. Processes included in Tally modeling scope are shown in bold. Italics indicate optional processes.
Office / Retail
Type III-B over IA Construction, IBC 2015
P2: Concrete Mat Slab Foundation
P1, L1: Concrete Slabs
L2: Concrete Podium Slab
L3: Roof: Mass Timber
Concrete Cores
30’ x 30’ Grid
Office / Retail
Type III-B over IA Construction, IBC 2015
P2: Concrete Mat Slab Foundation
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Concrete Cores
30’ x 30’ Grid

PLATTE FIFTEEN
Denver, Colorado
MASS TIMBER
(AS CONSTRUCTED)

STEEL

PT CONCRETE
The GWP is overwhelmingly dominated by this piece.

Floor assembly, (including topping) framing, columns
Total GWP/M² Per Life Cycle Stage

- [A1-A3] Product
- [A4] Transportation
- [B2-B8] Maintenance and Replacement
- [C2-C4] End of Life
- [D] Module D

Building Systems
- Mass Timber
- Steel
- Concrete
3490 km (2200 miles) from Quebec to Denver
BIOGENIC CARBON

STAGE A (NEGATIVE)

STAGE C & D
END OF LIFE

CRADLE TO GATE
CRADLE TO GRAVE

MATERIAL PHASE
BUILDING LIFESPAN
END OF LIFE

HARMFUL EMISSIONS REMAIN IN ATMOSPHERE PERMANENTLY & INCREASE RADIATIVE FORCING

MEANINGFUL CARBON STORAGE NO INCREASE IN RADIATIVE FORCING & LESS CARBON IN THE ATMOSPHERE

NET POSTIVE GWP IMPACT

50% carbon
Mix Assumptions for Wood:
- 63.5% Landfill
- 22.0% Incineration
- 14.5% Recycle
**Material Cost**

- Steel: Lowest = Baseline
- Concrete: Middle
- Mass Timber: Highest

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**DOLLAR COST**

**Cost Premium Over Steel (%)**

- Raw Material Installed:
  - Concrete System: 3.27%
  - Mass Timber System: 8.37%
MT CONSTRUCTION SPEED:
2,000 SF / DAY
6-8 WORKERS
Cost Premium Over Steel (%)

<table>
<thead>
<tr>
<th>Raw Material Installed</th>
<th>Concrete System</th>
<th>Mass Timber System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.27%</td>
<td>8.37%</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Structure Construction</th>
<th>Concrete System</th>
<th>Mass Timber System</th>
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<tbody>
<tr>
<td></td>
<td>3.9%</td>
<td>4.89%</td>
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</tbody>
</table>
Mass Timber:
Baseline time

Steel:
+ 2 months

Concrete:
+ 3.5 months

Cost Premium Over Steel (%)

- Raw Material Installed: 3.27% Concrete System, 8.37% Mass Timber System
- Structure Construction: 3.9% Concrete System, 4.89% Mass Timber System
- Whole Building Construction: 1.55% Concrete System, 1.95% Mass Timber System

DOLLAR COST & TIME COST
Structural System GWP and Whole Building Cost (%)

DOLLAR COST vs CARBON COST

Mass Timber: Baseline
Steel
Concrete

The Gap
DEVELOPMENT / BUILDING

CREDIT BUYER

CO$_2$

CO$_2$

CO$_2$

CO$_2$

CO$_2$

\$
Mass Timber:
Baseline time

Steel:
+ 2 months

Concrete:
+ 3.5 months

DOLLAR COST & CARBON COST

Cost Premium Over Steel (%)

<table>
<thead>
<tr>
<th>Category</th>
<th>Concrete System</th>
<th>Mass Timber System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Material Installed</td>
<td>3.27%</td>
<td>8.37%</td>
</tr>
<tr>
<td>(Δ = $2.89 / sf)</td>
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</tr>
<tr>
<td>Structure Construction</td>
<td>3.9%</td>
<td>4.89%</td>
</tr>
<tr>
<td>Whole Building Construction</td>
<td>1.55%</td>
<td>1.95%</td>
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<tr>
<td>Carbon Credit = $155,450 (0.35%)</td>
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</table>
Multifamily / Retail
Type IV-B Construction, IBC 2018 with Denver Amendments
12 Story
   No below grade
   L1: Drilled Piers + Concrete Slab on Grade
   L2-L4: Concrete Slabs
   L5 - Roof: Mass Timber
Concrete Cores
   20' x 20' Grid

RETURN TO FORM
Denver, Colorado
Multifamily / Retail
Type IV-B Construction, IBC 2018 with Denver Amendments
12 Story
No below grade
L1: Drilled Piers + Concrete Slab on Grade
L2-L4: Concrete Slabs
L5 - Roof: Mass Timber
Concrete Cores
20' x 20' Grid

RETURN TO FORM
Denver, Colorado
MASS TIMBER
(AS DESIGNED)

STEEL
(CFS & DECK)

PT CONCRETE
Total GWP/M² Per Life Cycle Stage

- Mass Timber
- Steel
- Concrete
Foundation GWP/M² Per Building System

- Mass Timber: 72% Substructure, 28% Superstructure
- Steel: 78% Substructure, 22% Superstructure
- Concrete: 80% Substructure, 20% Superstructure
1738 Metric Ton of CO₂eq

= 4.3 Million Miles Driven by Standard Vehicle
= 240 First Class Roundtrip Flights from Denver to London
= 335 Homes’ Electricity Use for 1 Year
= 5 Minutes for US and Canadian Forests to Grow
Office / Retail
Type III-B over IA Construction, IBC 2015
7 Story
  P2: Concrete Mat Slab Foundation
  P1, L1: Concrete Slabs
  L2: Concrete Podium Slab
  L3- Roof: Mass Timber
Concrete Cores
30’ x 30’ Grid

Multifamily / Retail
Type IV-B Construction
12 Story
  No below grade
  L1: Drilled Piers + Concrete Slab on Grade
  L2-L4: Concrete Slabs
  L5- Roof: Mass Timber
Concrete Cores
20’ x 20’ Grid

PLATTE FIFTEEN
&
RETURN TO FORM
Total GWP/M² Per Building System

<table>
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<th>Material</th>
<th>GWP/M² (kg CO₂ eq/m²)</th>
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<tbody>
<tr>
<td>Mass Timber</td>
<td>250</td>
</tr>
<tr>
<td>Steel</td>
<td>270</td>
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<tr>
<td>Concrete</td>
<td>300</td>
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Materials:
- Wood
- Metals
- Concrete
- Masonry
Total GWP/M² Above Podium Slab Per Building System

**Materials**
- Wood
- Metals
- Concrete
- Masonry

- Mass Timber
- Steel
- Concrete

**Graphs**

- **Left Graph**: Shows the GWP/M² for Mass Timber, Steel, and Concrete.
  - Mass Timber: Low GWP/M²
  - Steel: Medium GWP/M²
  - Concrete: High GWP/M²

- **Right Graph**: Illustrates the GWP/M² for Mass Timber, Steel, and Concrete with different materials.
  - Wood
  - Metals
  - Concrete
  - Masonry
• SYSTEM & MATERIAL COMPARISONS
• BAY LAYOUT COMPARISONS
• DEVELOP BASELINE
• IDENTIFY HOT SPOTS
• DEVELOP REDUCTION STRATEGIES

CONCEPTUAL DESIGN & QUANTIFICATION
## Life Cycle Stages & Study Scope

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Figure 3. Life Cycle Stages as defined by EN 15978. Processes included in Tally modeling scope are shown in bold. Italics indicate optional processes.
### SYSTEM COMPARISON

<table>
<thead>
<tr>
<th>TYPE</th>
<th>IV-MT</th>
<th>IV-MT</th>
<th>IV-MT</th>
<th>IV-C</th>
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<tr>
<td>BAY</td>
<td>20x32</td>
<td>30x30</td>
<td>30x32</td>
<td>29x32</td>
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### CONCEPTUAL DESIGN

#### TIMBER VOLUME (ft³/ft²)
- Baseline: 6.208
- 5% GWP: 5.555
- 10% GWP: 5.374

#### CONCRETE VOLUME (ft³/ft²)
- Baseline: 0.754
- 5% GWP: 0.726
- 10% GWP: 0.694

#### TIMBER VOLUME CHANGE
- Baseline: 6.208
- 5% GWP: 5.555
- 10% GWP: 5.374

#### CONCRETE VOLUME CHANGE
- Baseline: 0.754
- 5% GWP: 0.726
- 10% GWP: 0.694

**NOTES & DATA ASSUMPTIONS**

- U.S.G.EA. Standards for GWP and Biogenic Carbon Calculations
- GWP & Biogenic Carbon Calculations
- Structure Emission @ 90% Stress
- Structure Emission @ 80% Stress
- 20% Gross Arbors, 20% Fr. Ash
- 10% Gross Arbors, 10% Fr. Ash
- Self-standing UB/UB - 88% Gypsum Lime Plaster (Gly)
- Total System GWP is reported assuming Concrete with 10% Fr. Ash. Total GWP can be reduced by 17% if Concrete with 50% Fr. Ash is used.

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Table 2: Structural and Embedded Carbon System Comparison Results

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**CONCEPTUAL DESIGN**
CONCEPTUAL DESIGN
HOW TO LEVERAGE MASS TIMBER IN DESIGN

• COST
  • GRID EFFICIENCY
  • PANEL OPTIMIZATION
  • BEARING & SCREWED CONNECTIONS
  • FINISHES

• PREFABRICATION
  • PANELIZED SYSTEM
  • COORDINATE & PRECUT

• SPEED OF CONSTRUCTION
  • CORE WALLS CRITICAL PATH
  • PREFABRICATED/ PANELIZED FAÇADE
  • PANEL SEQUENCING
  • TEMPORARY PROTECTION

• DESIGN FOR DISASSEMBLY / EASE OF DECONSTRUCTION & RECOVERY
MASS TIMBER IS SUSTAINABLE...

• LOW EMBODIED CARBON
• STORES CARBON
• RENEWABLE
• REUSABLE

EASE OF DECONSTRUCTION & RECOVERY
UNDER CONSTRUCTION, MASS TIMBER...

- IS FAST
- IS QUIET
- IS LIGHTER
- REQUIRES LIMITED LABOR
- HAS LITTLE WASTE
- REDUCES CONSTRUCTION TRAFFIC
IN THE FINISHED BUILDING, MASS TIMBER...

• IS HEALTHY - CREATES BIOPHILIC ENVIRONMENT

• NATURAL AESTHETIC

• HIGH LEASE RATES

• HIGH LEASING VELOCITY

• ADVANCES DEVELOPER BRANDING, ESG COMMITMENTS

• EARN CARBON CREDITS, GREEN FINANCING

Photo Credit: KL&A
MASS TIMBER INDUSTRY...

- ENCOURAGES FOREST HEALTH & MAINTENANCE
- SUPPORTS RURAL ECONOMIES
- LEVERAGES BIOMIMICRY
- RESPONDS TO SOCIETAL DEMAND FOR SUSTAINABLE CONSUMER PRODUCTS
THANK YOU

Alexis Feitel, PE, Team Carbon Unit Director & Structural Engineer  afeitel@klaa.com