

Forest to Floor Plate: Mass Timber's Carbon, Cost, and Schedule Performance

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Principal and Embodied Carbon
Operations Director
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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.



Course Description

As the building industry pursues meaningful decarbonization, mass timber has emerged as one of the most immediate strategies for reducing the embodied carbon of the structural system. Drawing on WoodWorks' Mass Timber Comparative Life Cycle Assessment Series, this presentation examines four U.S. reference projects: Return to Form, the Nez Perce-Clearwater National Forests Supervisor's Office, the Burwell Center for Career Achievement, and a Denver office building. Each was benchmarked against a functionally equivalent steel or concrete alternative using whole-building life cycle assessment.

Findings are consistent and compelling. Mass timber structural systems delivered whole-building global warming potential (GWP) savings of 22 to 50 percent, rising even higher when isolating the superstructure and above-podium scopes. Every project realized a faster construction schedule, with mass timber alternatives completing up to 4.2 months ahead of conventional designs, while construction cost premiums remained modest at 0 to 7 percent. Biogenic carbon stored in the wood components offsets emissions equivalent to driving tens of millions of miles in a passenger vehicle. The session will translate these results into practical guidance for architects, engineers, developers, and owners working to align cost, schedule, and climate goals on real buildings.

Learning Objectives

1. Explain how whole building LCA is used to compare the embodied carbon performance of mass timber, steel, and concrete structural systems.
2. Interpret comparative LCA results to evaluate the effects of structural material selection on global warming potential (GWP) and biogenic carbon storage.
3. Assess the influence of mass timber structural systems on construction cost and project schedule using data from four case studies.
4. Apply findings from comparative LCAs to support material selection decisions that balance embodied carbon reduction, project cost, and construction efficiency.

CASE STUDY SERIES

USDA U.S. Forest Service,
Softwood Lumber Board,
WoodWorks, KL&A Team Carbon

Mass Timber Comparative Life Cycle Assessment Series

Trends and Conclusions

Author: KL&A Engineers & Builders



RTF

Multifamily / Retail

Type IV-B Construction

139,000 ft² (12,900 m²)

12 Story

BURWELL

Office / Higher Ed

Type III-B Construction

22,990 ft² (2,136 m²)

3 Story

NEZ PERCE

Office

Type V-B Construction

16,045 ft² (1,491 m²)

2 Story

BUILDINGS

DENVER OFFICE

Office / Higher Ed

Type III-A Construction

98,280 ft² (9,130 m²)

4 Story

P15

Office / Retail

Type III-B over IA Construction

150,000 ft² (14,000 m²)

7 Story

Platte Fifteen
Life Cycle Assessment



Author:
S&B Engineers and Builders
Austin-Pace & Peterson

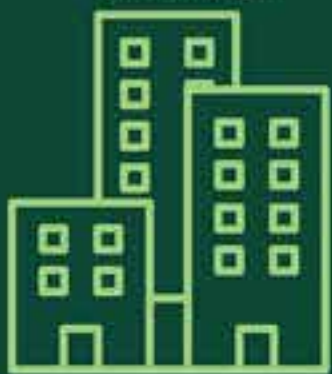




Production Stage



Construction Stage



Use Stage



End-of-Life Stage



Mass Timber Comparative Life Cycle Assessment Series

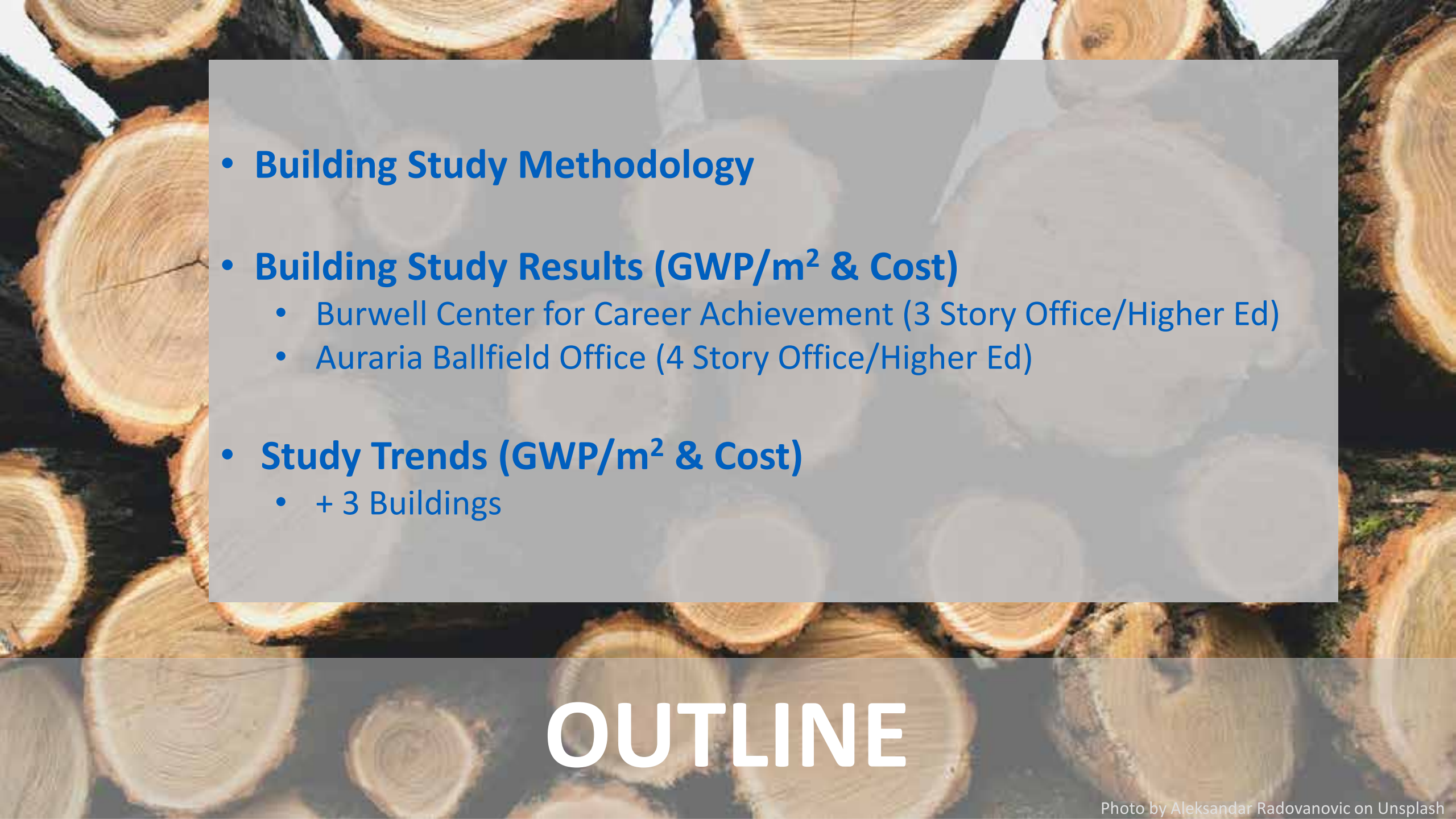
Comparing the embodied carbon impacts and cost of mass timber buildings to functionally equivalent buildings

Introduction



Author

KL&A Engineers & Builders / KL&A Team Carbon

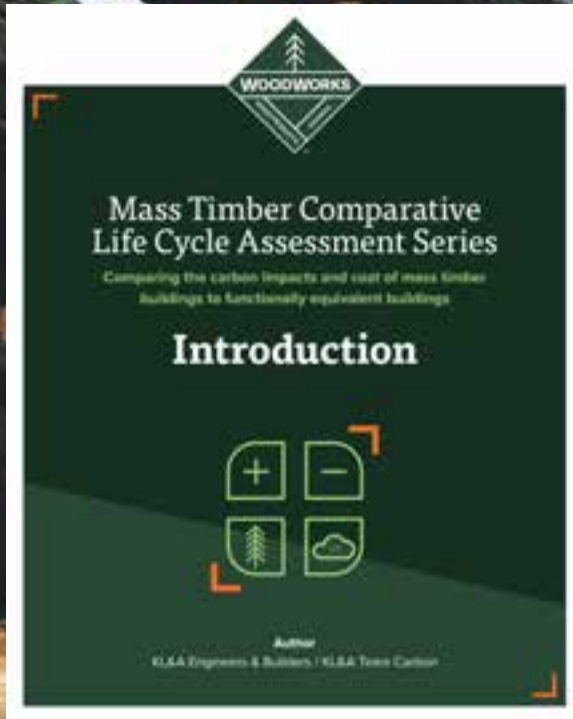
- 
- **Building Study Methodology**
 - **Building Study Results (GWP/m² & Cost)**
 - Burwell Center for Career Achievement (3 Story Office/Higher Ed)
 - Auraria Ballfield Office (4 Story Office/Higher Ed)
 - **Study Trends (GWP/m² & Cost)**
 - + 3 Buildings

OUTLINE



- “Buckle Up for Bar Charts”
– Alexis Feitel
- Mass Timber Strategy &
Execution with Cambium

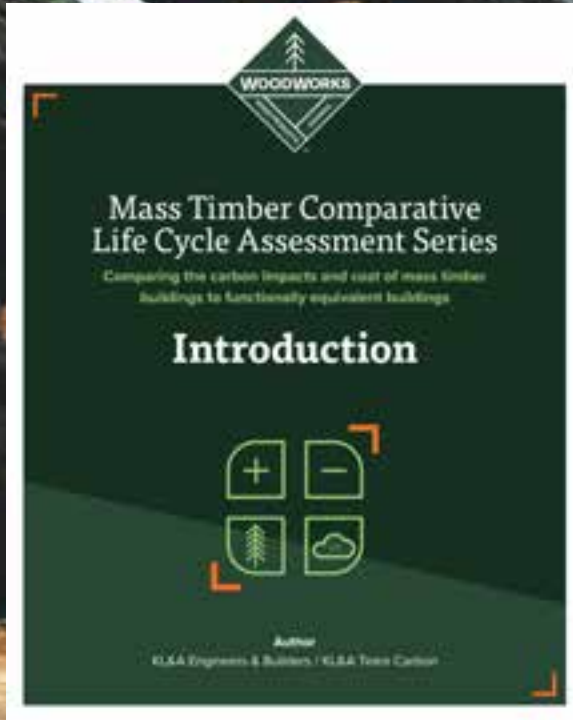
CREDIT AND THANKS



- **Comparative Design**

- Functionally Equivalent (ISO 14044 4.2.3.7 & ASTM E2921)
- Construction Type
 - Fire Resistance Rating
- Design Efficiencies & Considerations
 - Framing Scheme
 - Span Lengths
 - Grid Layout → Eliminate Transfer Podiums
 - Floor Assembly Thicknesses → Building Height
 - Building Weight → Foundations, Lateral System
 - Acoustic Assembly
 - Ceiling Assembly

BUILDING STUDY METHODOLOGY



- **Comparative WBLCA**

- TallyLCA 
- Biogenic Carbon Methodology
- Scope
 - Structure
 - Enclosure
 - FRR
 - Acoustic
 - Ceiling Finishes
- System Boundary: Cradle-to-Grave (A-C, plus Module D)
- Data: Methodology, Assumptions, End-of-Life, Uncertainty

- **Comparative Cost & Speed of Construction**

- Normalized Material & Labor Costs

BUILDING STUDY METHODOLOGY



CRADLE TO “CRADLE”

CRADLE TO GRAVE

CRADLE TO GATE

Production			Construction		Use							End-of-Life				Module D		
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D1	D2	D3
Raw Material Supply	Transportation	Manufacturing	Transportation	Construction/Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	Deconstruction/Demolition	Transportation	Waste Processing	Disposal	Reuse	Recycling	Energy Recovery

Note that the stages and information modules shown here deviate slightly from the naming convention used in ISO 21930. However, this series generally uses terminology consistent with ISO 21930.



Sustainable Sourcing

- ISO 21930 7.2.11

-1/+1 Static Accounting

- ISO 21930 7.2.7

TallyLCA EOL Allocation



- 32% Permanently Stored

Material	Incineration	Landfill	Recycling / Recovery	Accounting Method
Concrete		45%	55%	Recycled into aggregate, credited for avoided burden of production of aggregate, considers impact of grinding energy
Steel & Reinforcement		2%	98%	Recycled virgin material is credited for avoided burden of production (net scrap), considers processing impacts
Mass Timber	22%	63.5%	14.5%	Incineration is credited for energy recovery, landfill considers 50% decomposition and release of biogenic carbon (with credit for energy recovery due to landfill gas capture) and 50% is permanently stored, recycling is credited as avoided burden, considers impact of grinding energy
Glass		100%		
Gypsum Board		100%		
Plastic		100%		
Insulation		100%		

Image by WoodWorks

BIOGENIC CARBON METHODOLOGY

Return To Form

Comparative Life Cycle Assessment Study

Author: KL&A Engineers & Builders



Image by WoodWorks

Multifamily / Retail

Type IV-B Construction, IBC 2018 with Denver Amendments (2024 IBC)

139,000 ft² (12,900 m²)

12 Story

Foundations: Drilled Piers

No below grade

L1: Concrete Slab on Grade

L2-L4: Concrete Slabs

L5 - Roof: CLT Panel & Glulam

Lateral: Concrete Cores

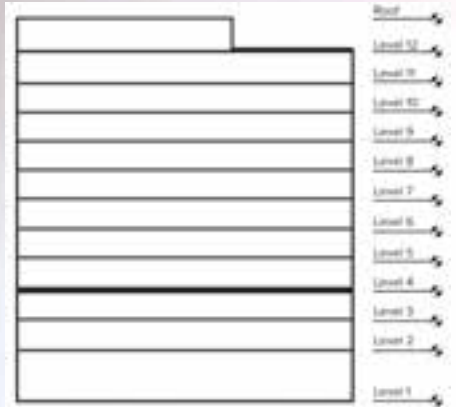
Grid: 20' x 20'

Owner: Katz Development

Architect: tres birds

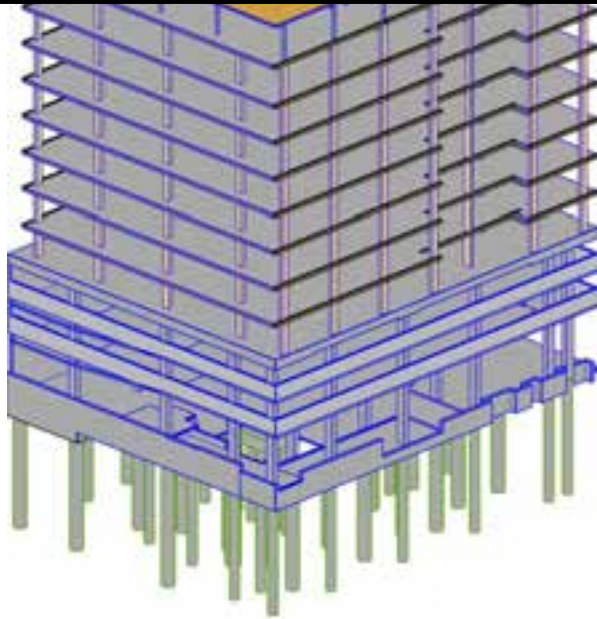
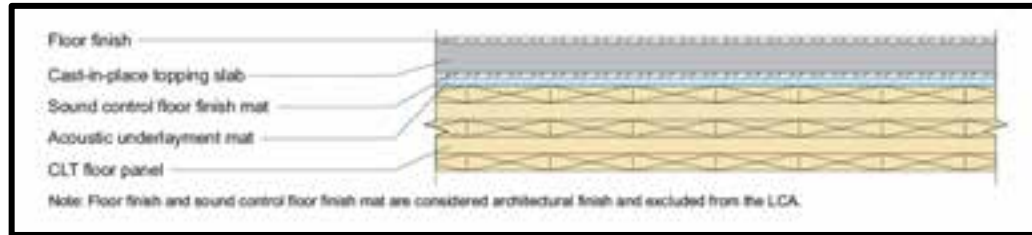
Engineer: KL&A

Contractor: Swinerton, Timberlab

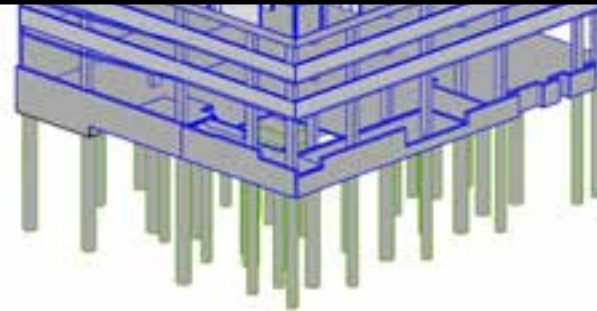
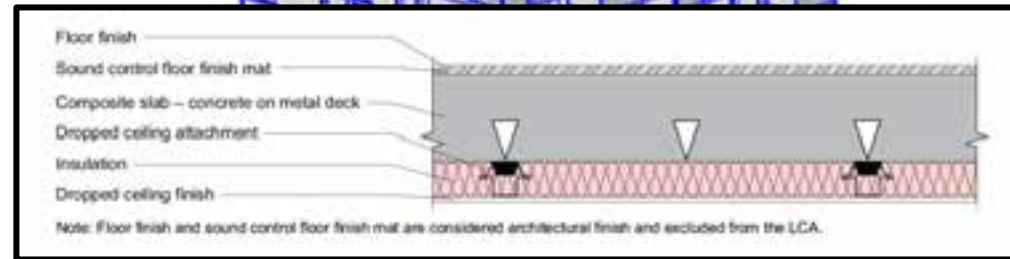


RETURN TO FORM

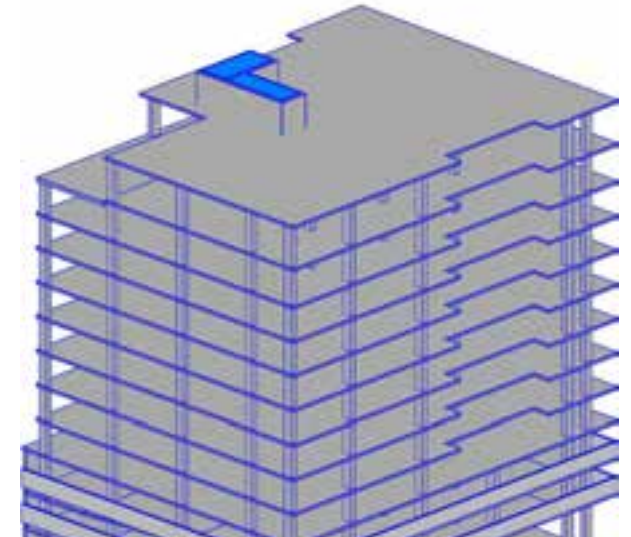
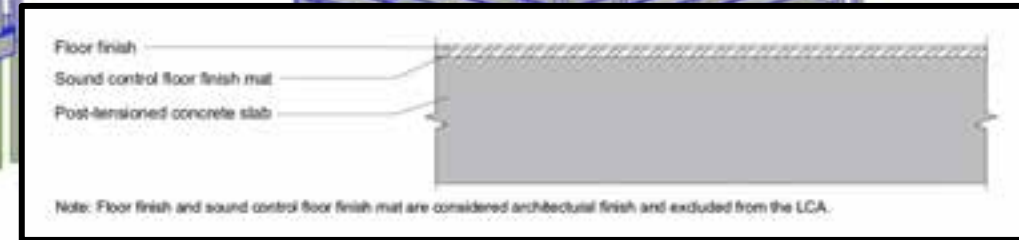
Denver, Colorado



MASS TIMBER
(AS DESIGNED)
Type IV-B



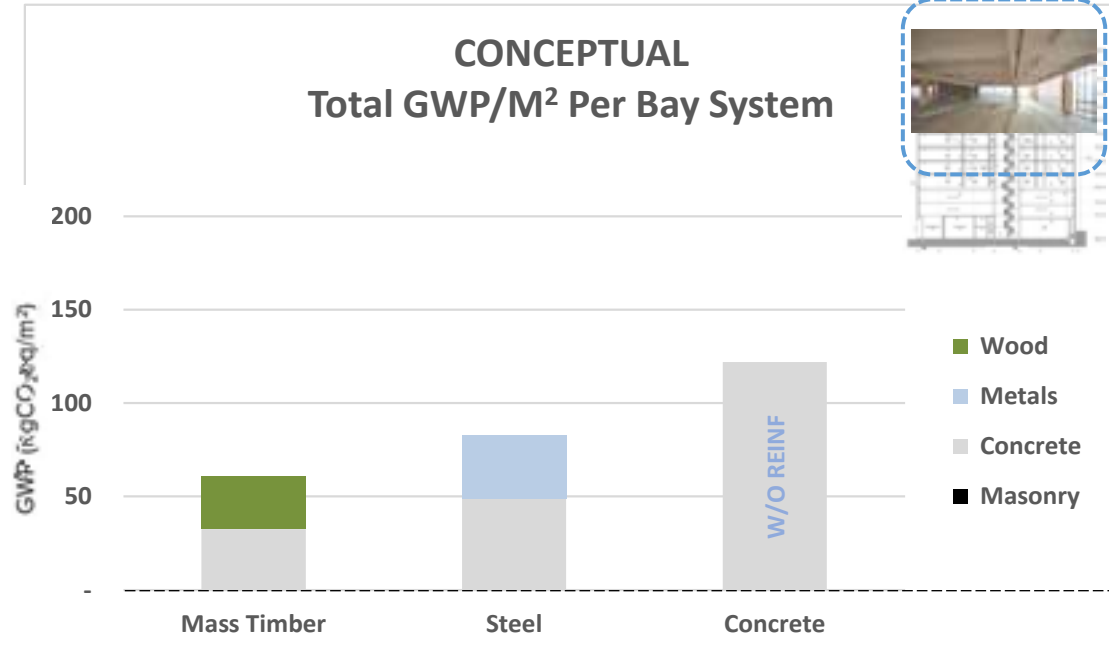
STEEL "CFS"
(CFS & DECK)
Type I-B



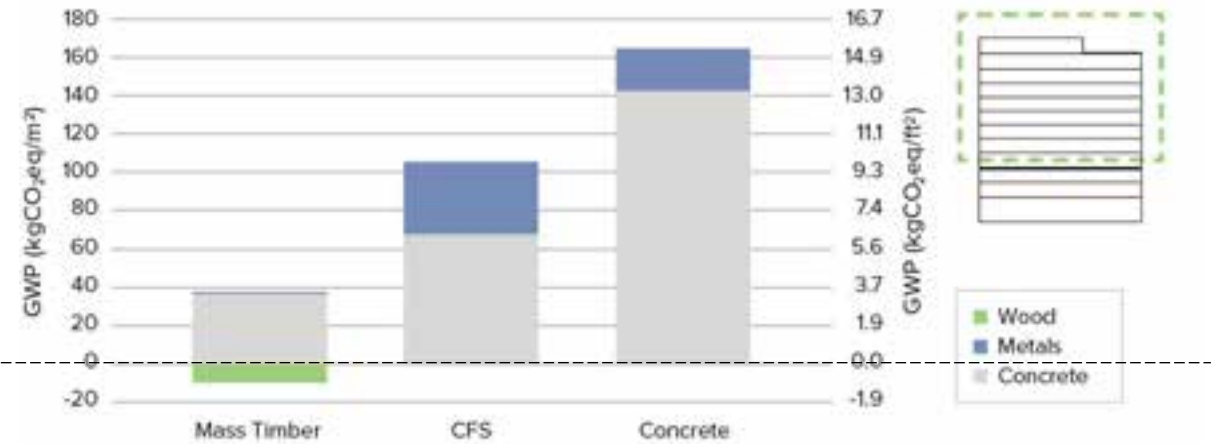
CONCRETE
(PT)
Type I-B

RETURN TO FORM

(SINGLE FRAMING BAY)



(WITHOUT BIOGENIC CARBON)



EARLY DESIGN

Prestandard for Assessing the Embodied Carbon of Structural Systems for Buildings

Task Committee on Embodied Carbon Assessment
of Structural Systems in Buildings

ASCE

Edited by
Jay Arehart, Ph.D.



EARLY DESIGN-PHASE EMBODIED CARBON REDUCTIONS

Guidance on an approach for early design-phase global warming potential estimates, using EPDs, to reduce the embodied carbon of buildings.

Author: KL&A Engineers & Builders, Team Carbon



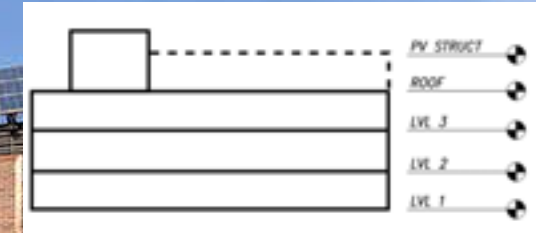
KL&A
Engineers & Builders

EARLY DESIGN

Office / Higher Education
Type III-B Construction
22,990 ft² (2,136 m²)
3 Story

Foundations: Drilled Piers
No below grade
L1: Concrete Slab on Grade
L2 – Roof: CLT Panel & Glulam
Lateral: CLT Panel Walls at Core
Grid: 11' X 24'

Owner: University of Denver
Architect: Lake Flato, Shears Adkins Rockmore
Engineer: KL&A
Contractor: PCL



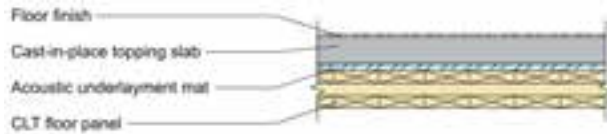
Burwell Center for Career Achievement

Denver, Colorado

MASS TIMBER (AS CONSTRUCTED, 2020)

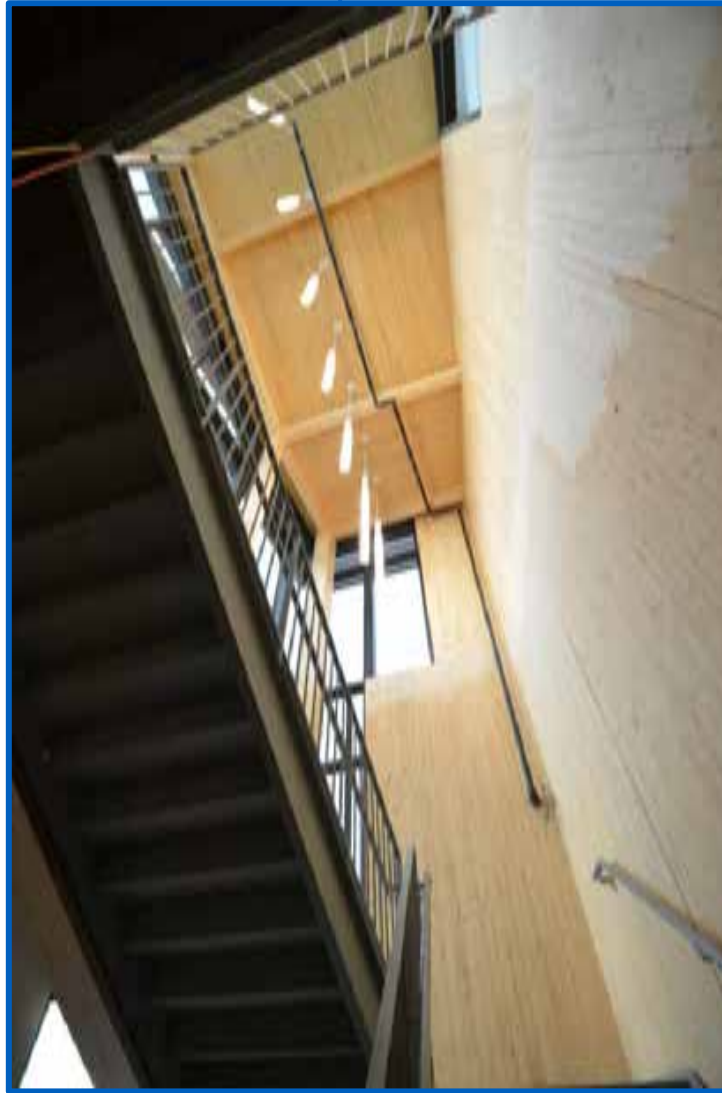
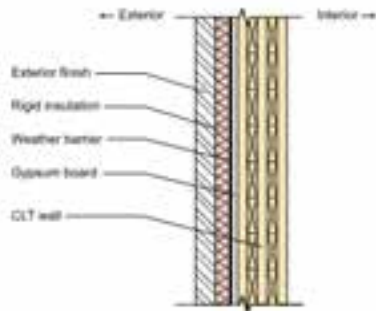


FLOOR: 3ply CLT Floor, Concrete Topping Slab, Glulam Framing



ROOF: 3ply CLT, Glulam Framing

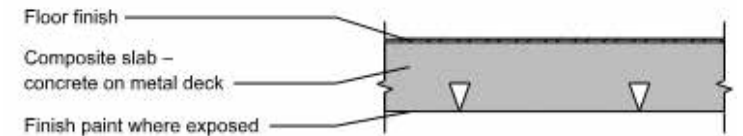
LATERAL: 5ply CLT Core Walls



STEEL (DESIGN OPTION)



FLOOR: Concrete on Metal Deck, WF Framing



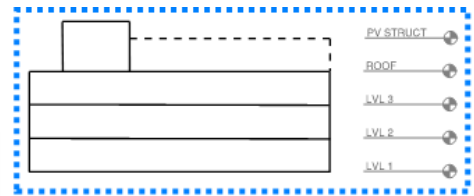
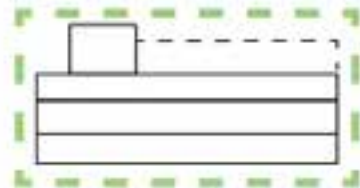
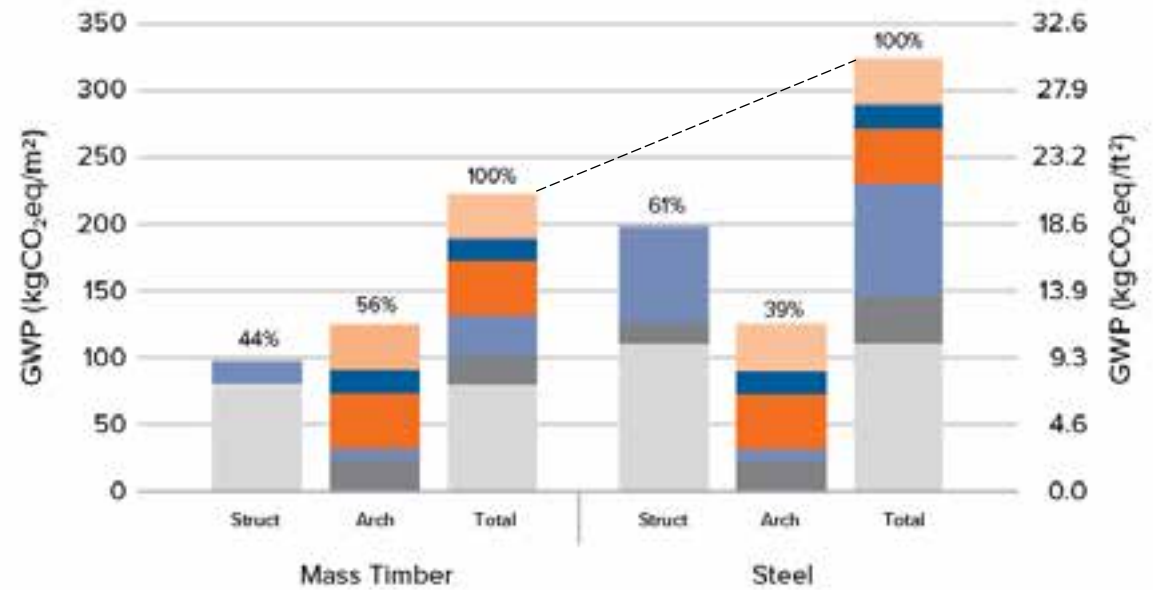
ROOF: Metal Deck, WF Framing

LATERAL: CMU Core Walls & Steel Brace



MT < STEEL
31% REDUCTION

**Total Building GWP –
System and Material Contributions**



MT
224 kgCO₂eq/m²

STEEL
324 kgCO₂eq/m²

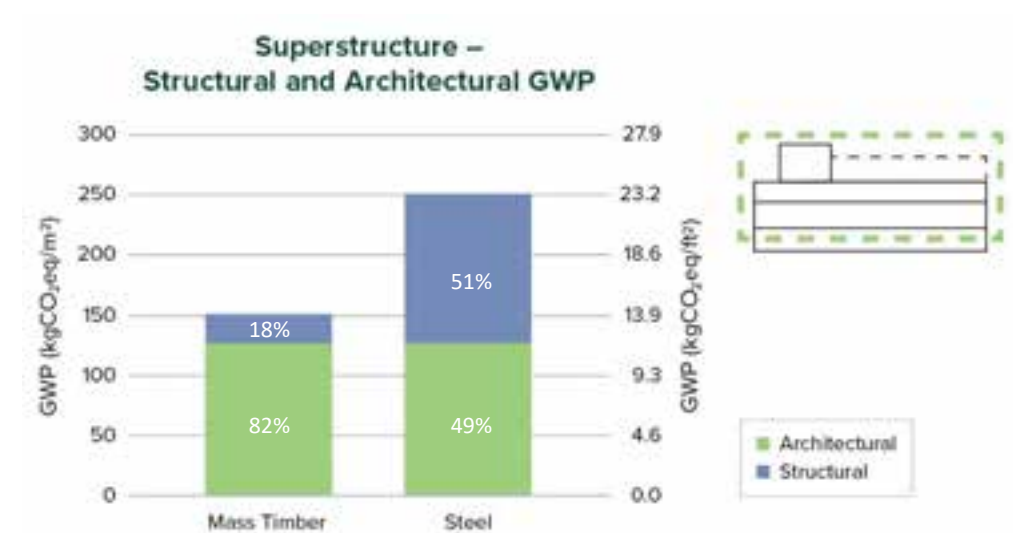
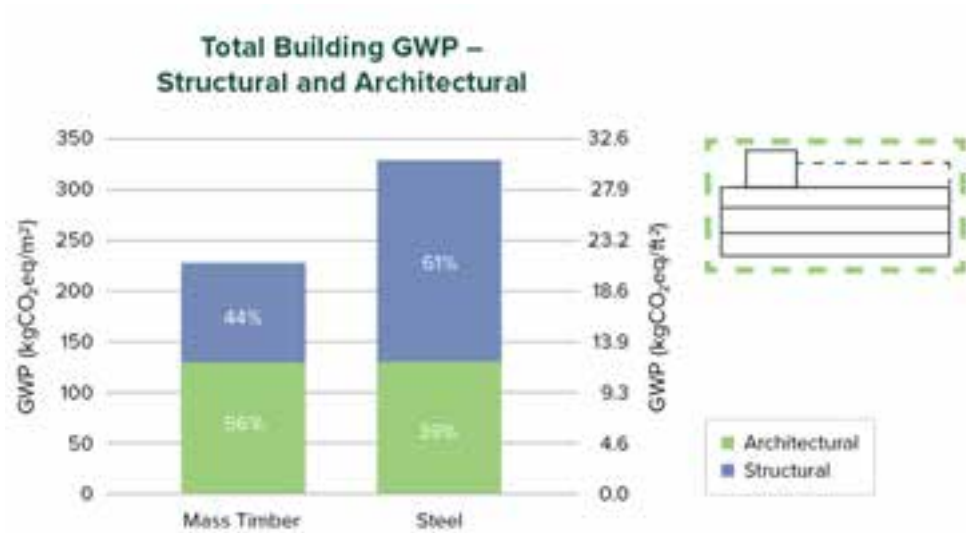
ARCHITECTURE
ONLY

0.2% REDUCTION

BURWELL – TOTAL GWP

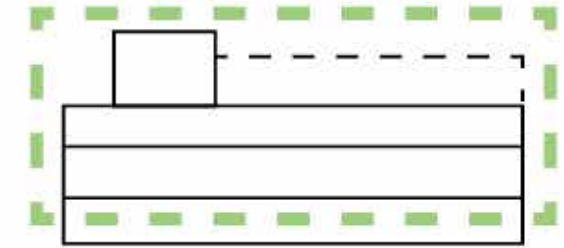
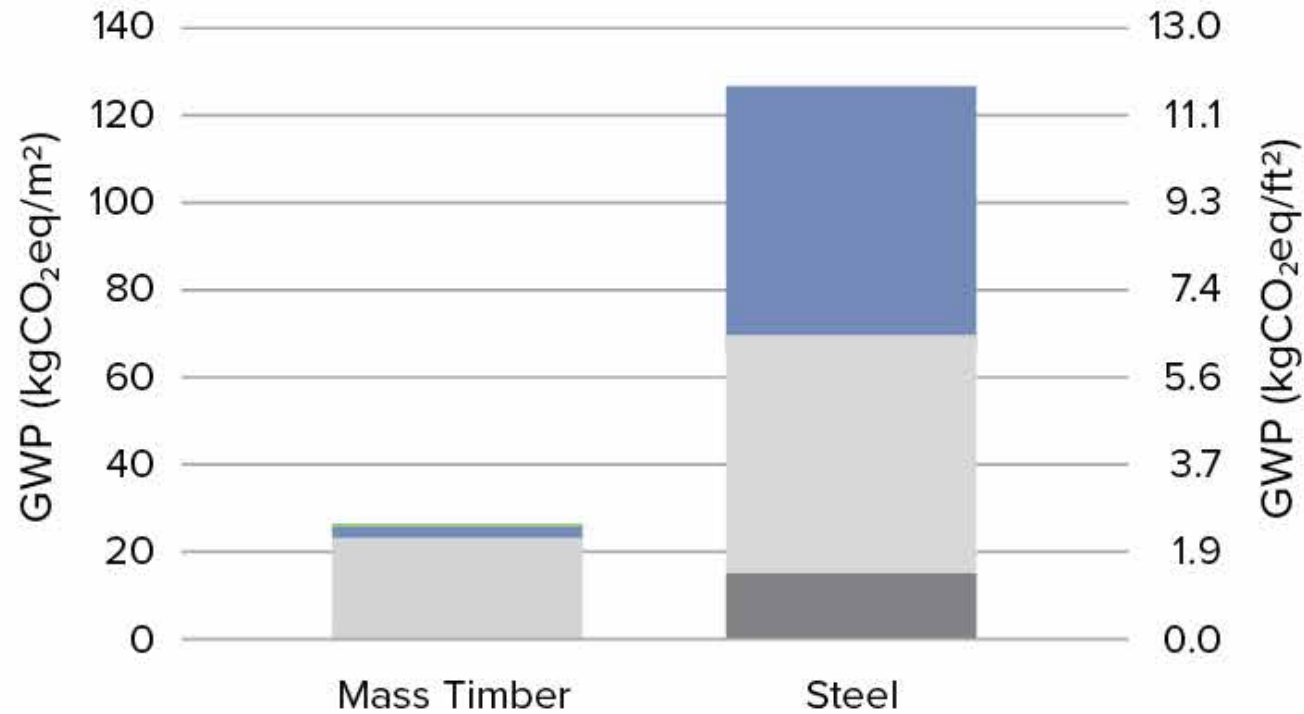


MT < STEEL
40% REDUCTION



BURWELL – STRUCTURE vs ARCHITECTURE

Superstructure Structural GWP



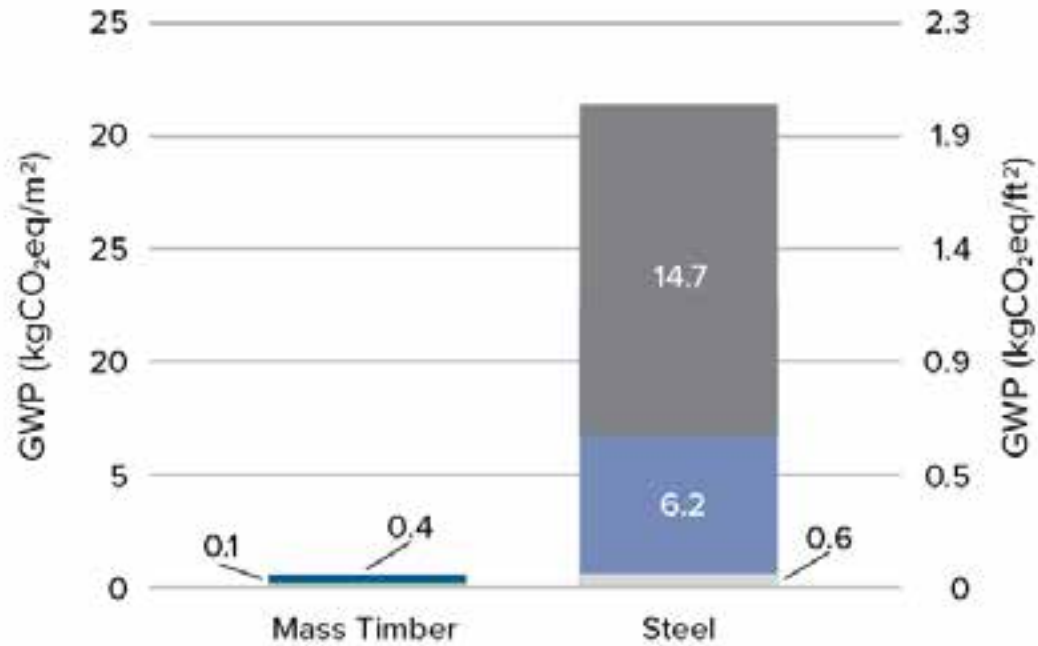
MT < STEEL
79% REDUCTION

Concrete Volume
38% Reduction
2% Foundation

BURWELL – STRUCTURE SUPERSTRUCTURE



Lateral System Component Contributions



MT < STEEL
98% REDUCTION

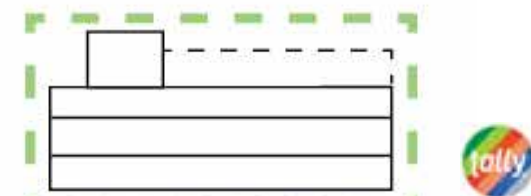
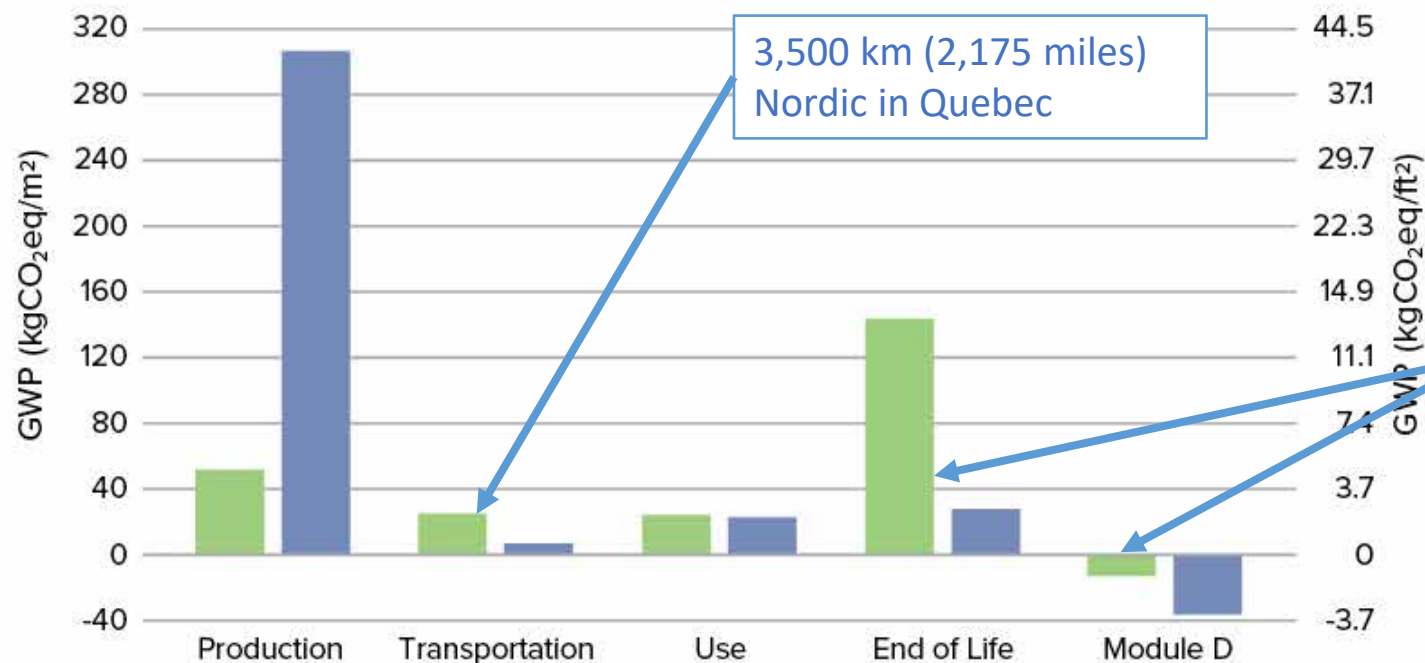


BURWELL – LATERAL SYSTEM



A4 = 10% of Stored
Biogenic Carbon

Total Building GWP per Life Cycle Stage



Mix Assumptions for Wood:

32% Permanently Stored

- 63.5% Landfill
- 22.0% Incineration
- 14.5% Recycle

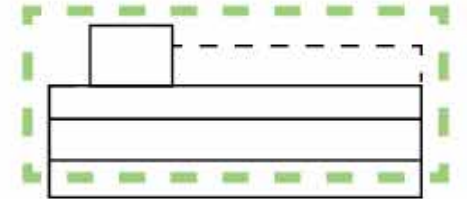
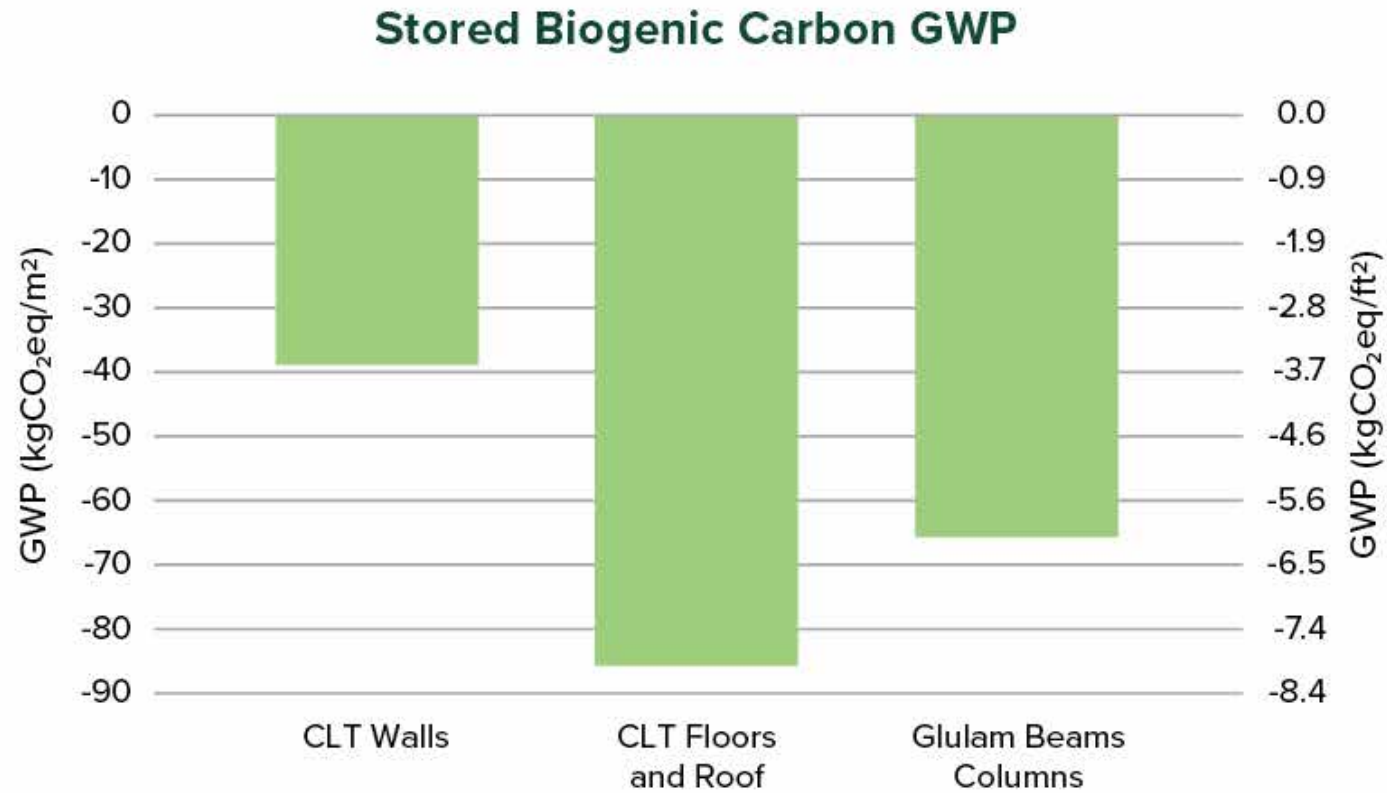
■ Mass Timber
■ Steel

A4 = 9% TOTAL MT GWP
A4 = 2% TOTAL STL GWP

BURWELL – LCA STAGES

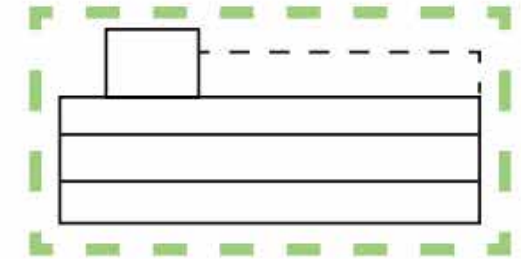
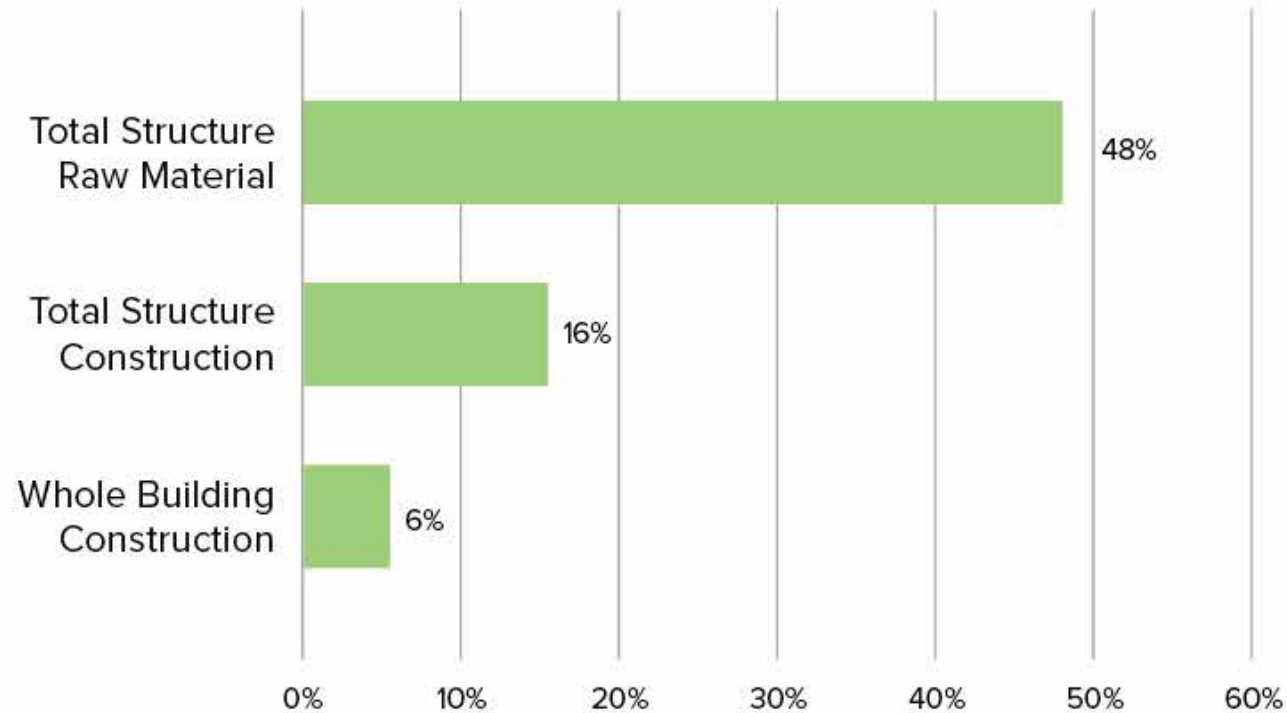


-192 kgCO₂eq/m²
vs
224-324 kgCO₂eq/m²



BURWELL – BIOGENIC CARBON

Construction Cost



Core Walls

**MT 12 Days Faster
than CMU**

■ Mass Timber
■ Steel



6% \$ Premium

32 Days Faster

BURWELL – COST & SCHEDULE

Office / Higher Education
Type III-A Construction
98,280 ft² (9,130 m²)
4 Story

Foundations: Spread Footings

No below grade

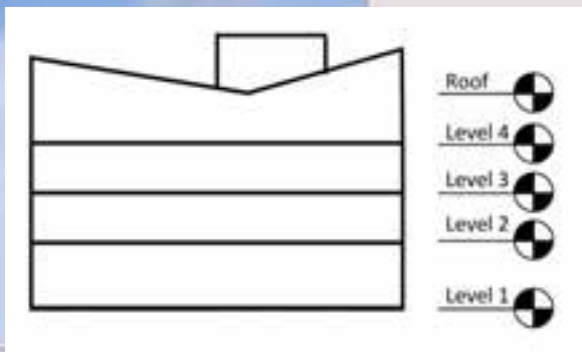
L1: Concrete Slab on Grade

L2 – Roof: CLT Panel & Glulam

Lateral: Precast Concrete Core Walls + Glulam Brace

Grid: 20' X 34'

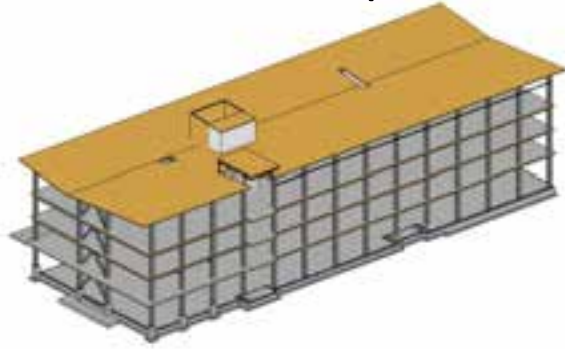
Owner: Columbia Ventures
Architect: Shears Adkins Rockmore
Engineer: KL&A
Contractor: PCL



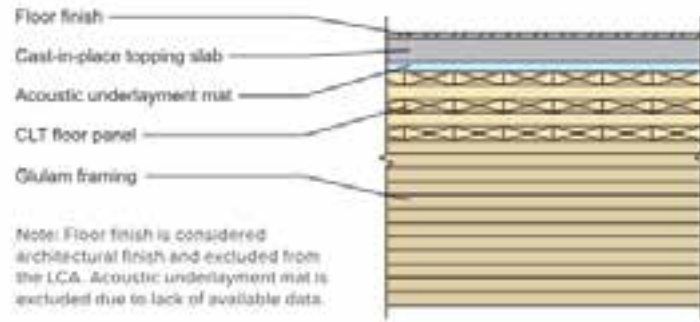
Denver Office

Denver, Colorado

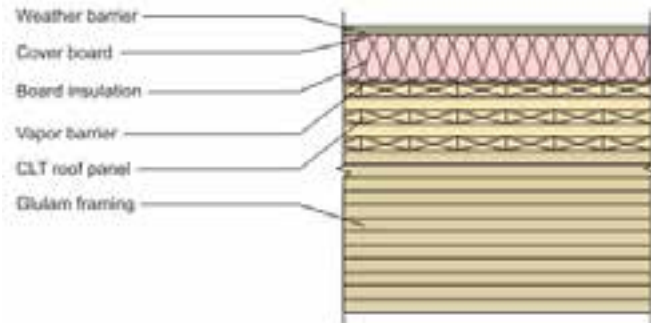
MASS TIMBER (AS DESIGNED)



FLOOR: 5ply CLT Floor, Concrete Topping Slab, Glulam Framing



ROOF: 5ply CLT, Glulam Framing



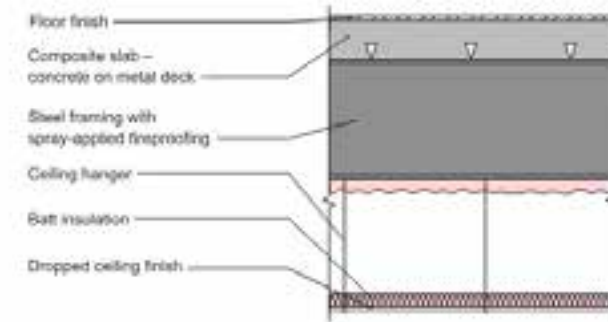
LATERAL: Precast Concrete Walls, Glulam Brace



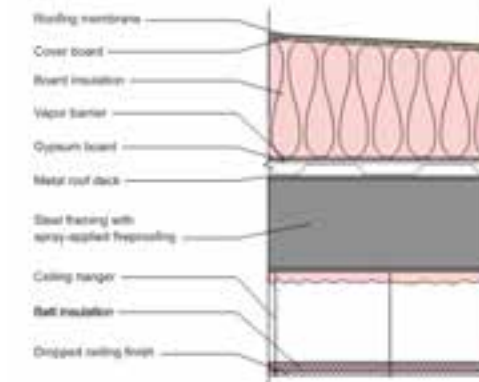
STEEL (DESIGN OPTION)



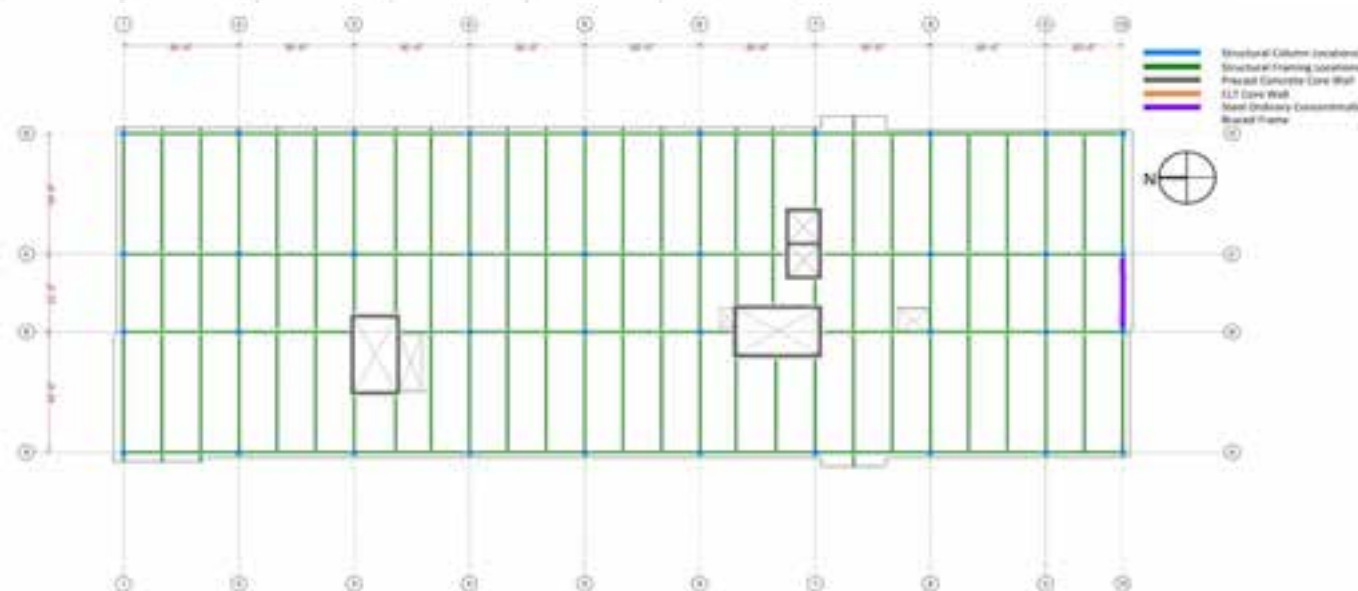
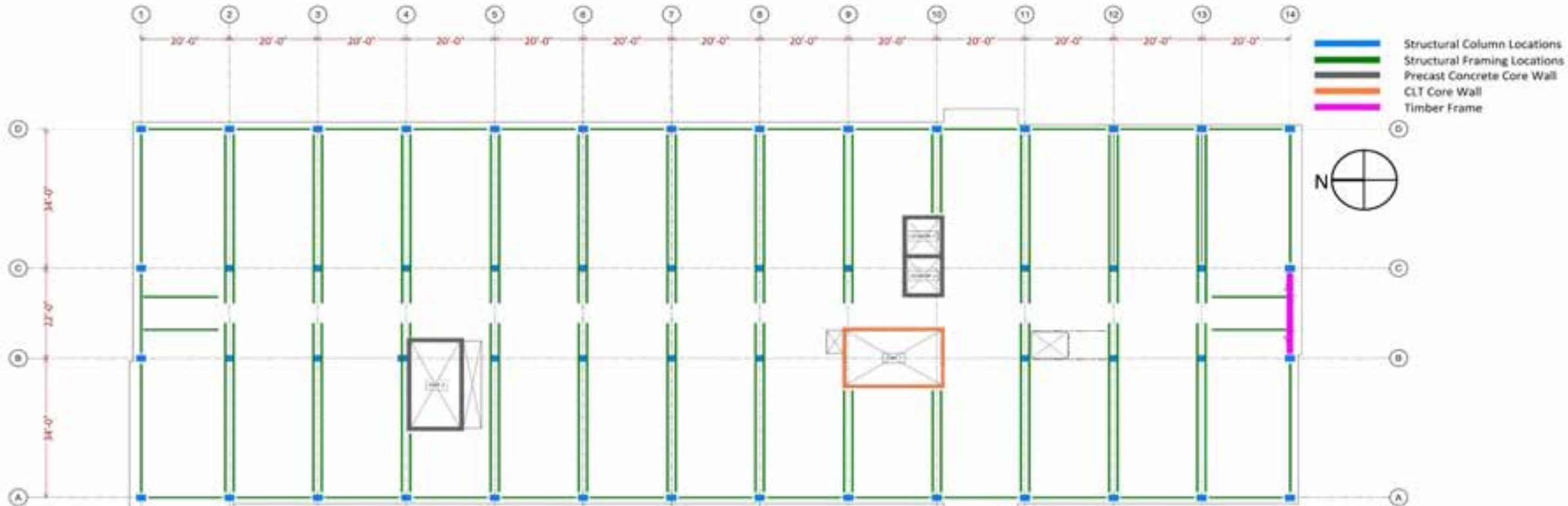
FLOOR: Concrete on Metal Deck, WF Framing



ROOF: Metal Deck, WF Framing



LATERAL: Precast Concrete Walls, Steel Brace

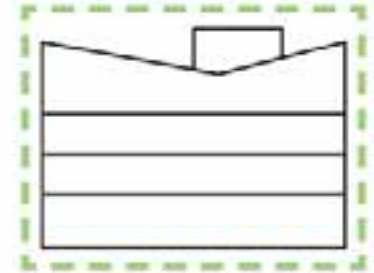
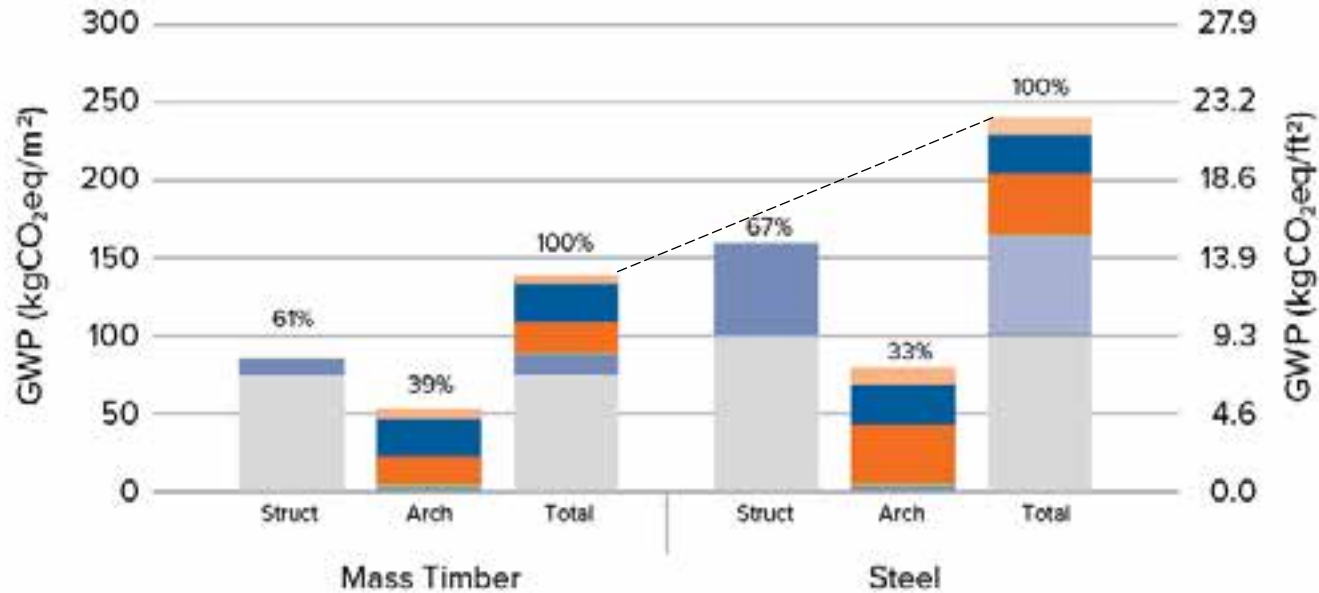




MT < STEEL
42% REDUCTION

Concrete Volume
17% Reduction

Total Building GWP –
System and Material Contributions



MT
140 kgCO₂eq/m²

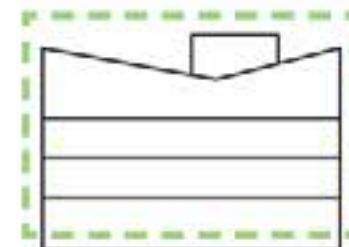
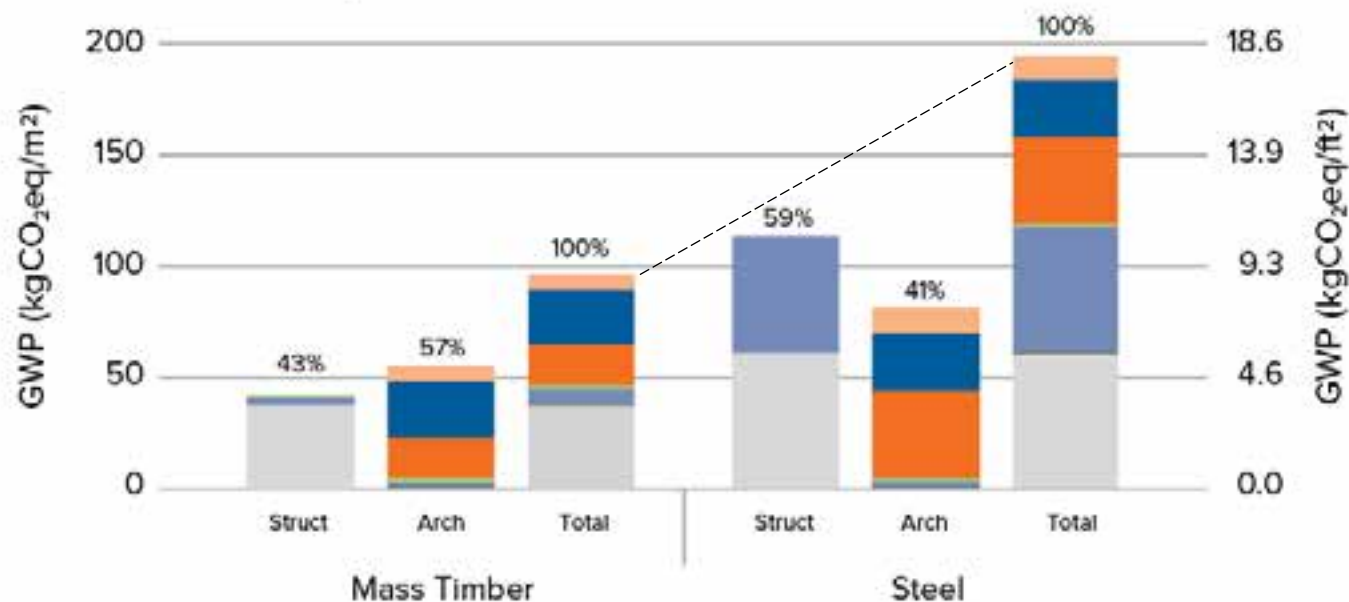
STEEL
239 kgCO₂eq/m²

DENVER OFFICE – TOTAL GWP



MT < STEEL
50% REDUCTION

Superstructure GWP –
System and Material Contributions



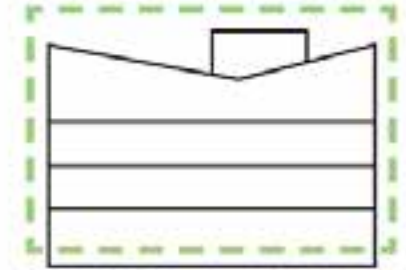
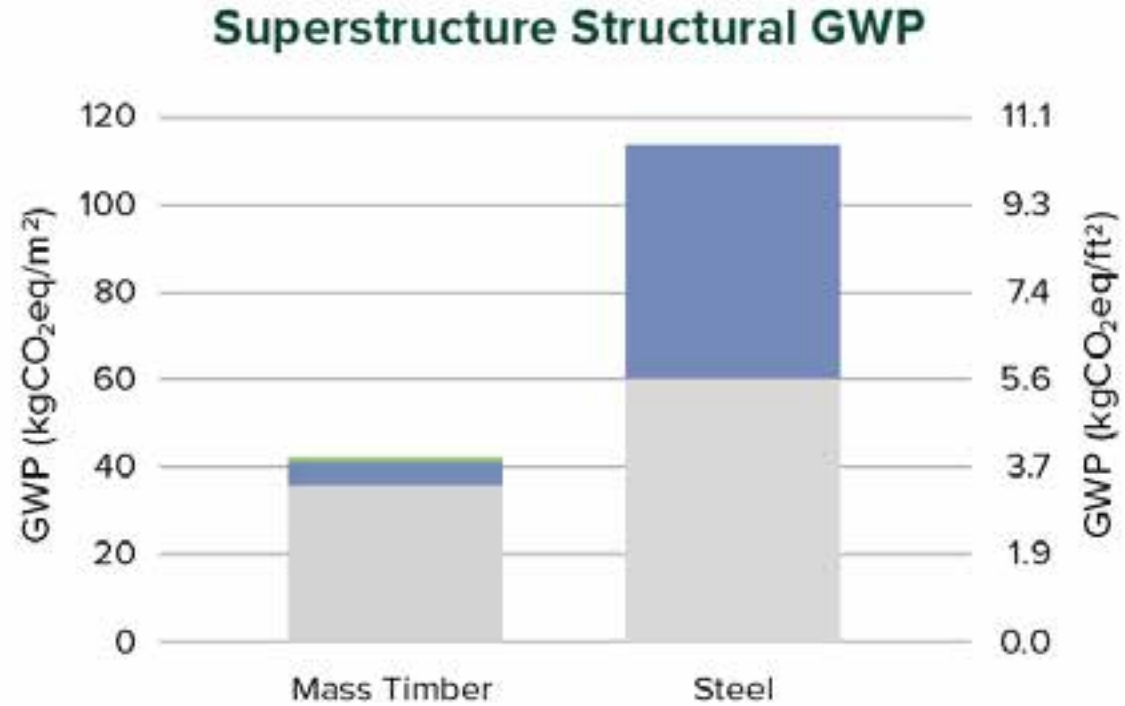
ARCHITECTURE
ONLY

32% REDUCTION

DENVER OFFICE – SUPERSTRUCTURE



MT < STEEL
63% REDUCTION

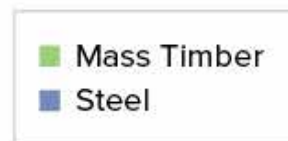
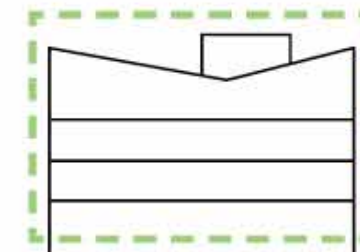
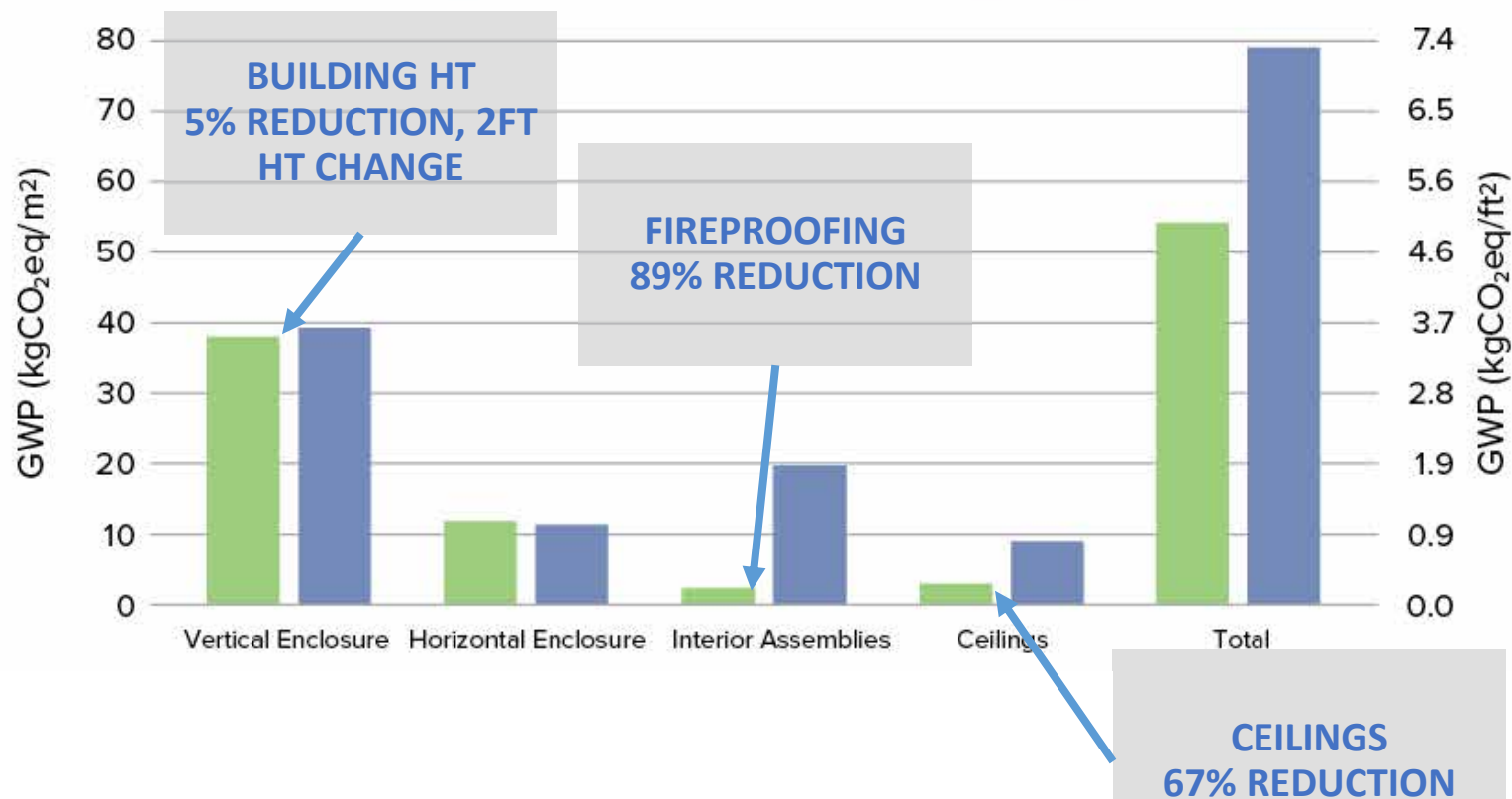


DENVER OFFICE – STRUCTURE SUPERSTRUCTURE



**MT < STEEL
32% REDUCTION**

Superstructure Architectural GWP

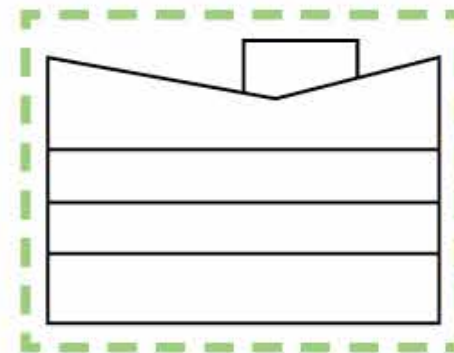
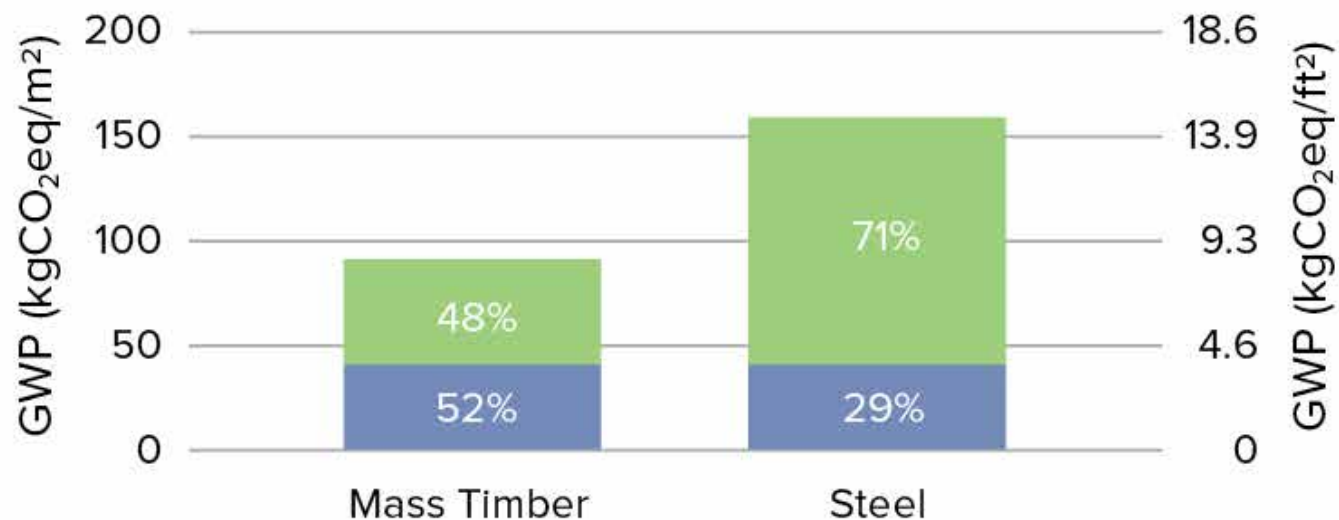


DENVER OFFICE – ARCHITECTURAL



Significant
Foundation Impact

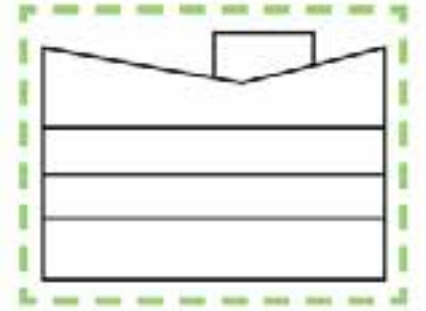
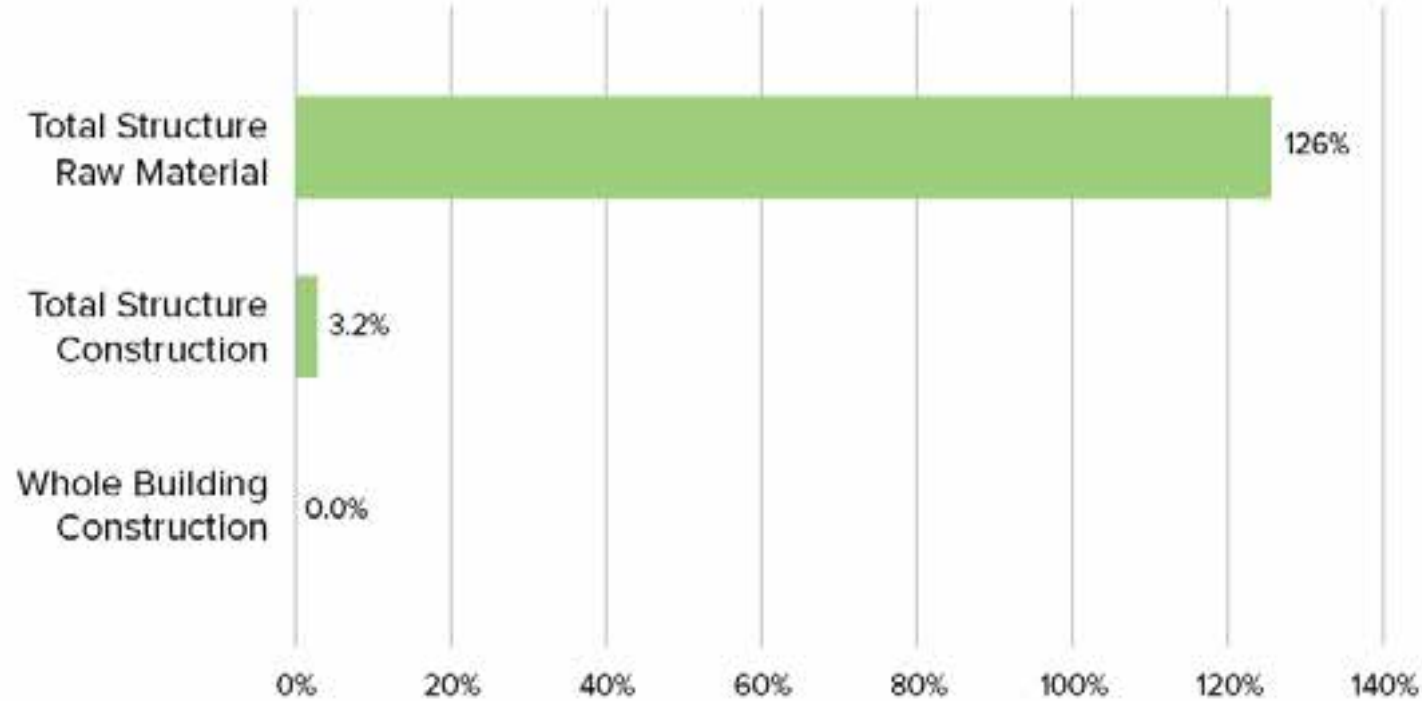
Structural Substructure and Superstructure GWP



■ Superstructure
■ Substructure

DENVER OFFICE – SUBSTRUCTURE vs SUPERSTRUCTURE

Construction Cost



Mass Timber

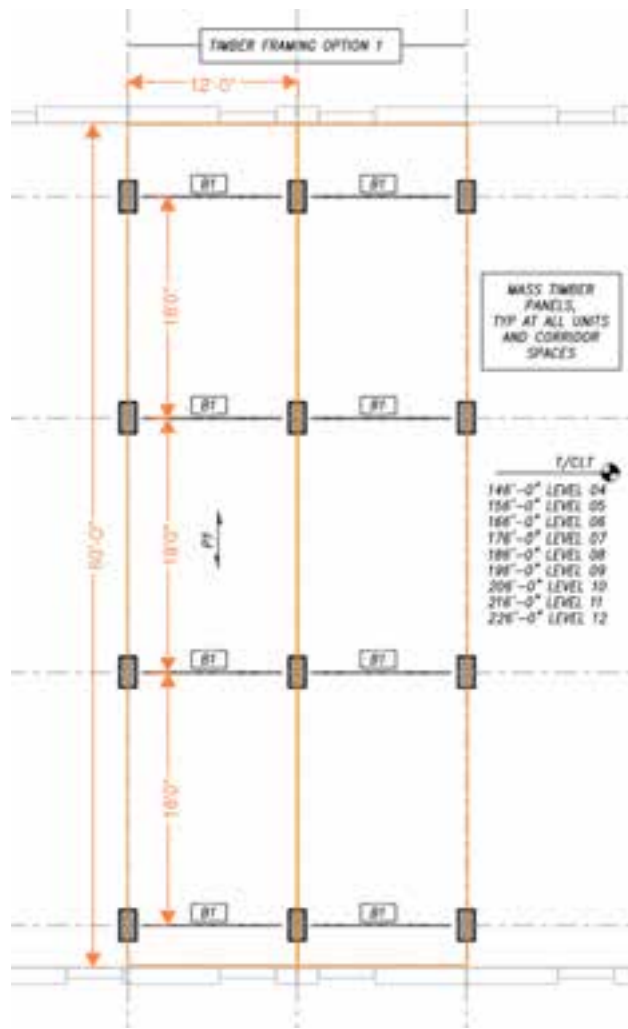
0% \$ Premium

2.5 Months Faster

DENVER OFFICE – COST & SCHEDULE



**DENVER OFFICE -> SUMMIT
HOUSE DORMATORY**



**DENVER OFFICE -> SUMMIT
HOUSE DORMATORY**

NEZ PERCE-CLEARWATER NATIONAL FORESTS SUPERVISOR'S OFFICE KAMIAH, ID

Office

Type V-B Construction

16,045 ft² (1,491 m²)

2 Story

Foundations: Spread Footings

Partial Below Grade

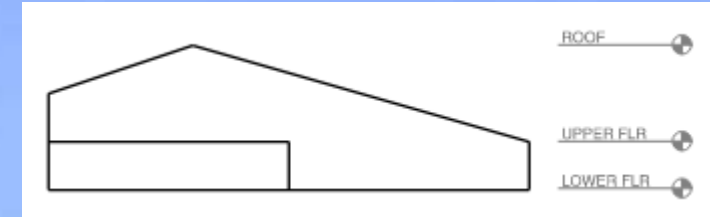
L1: Concrete Slab on Grade

L2: Partial, Light Frame Wood & MT Hybrid

Roof: CLT Panel & Glulam

Lateral: Light Frame Wood Shear Walls

CLT Elevator Walls



Owner: U.S. Forest Service

Architect: Mosaic Architecture

Engineer: Morrison-Maierle

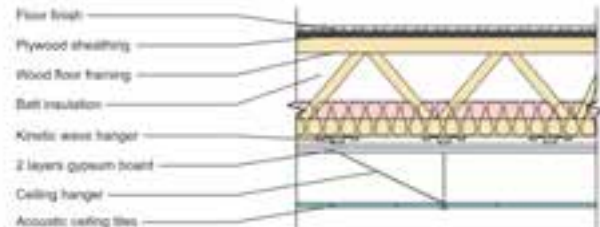
Contractor: Quality Contractors



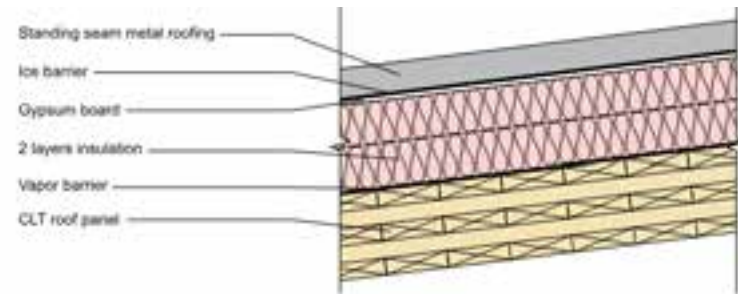
MASS TIMBER – LIGHT FRAME HYBRID (AS CONSTRUCTED, 2021)



FLOOR: Plywood Sheathing, I-Joists, Glulam Beams (No Topping Slab)



ROOF: 4ply CLT, Glulam Beams & Columns



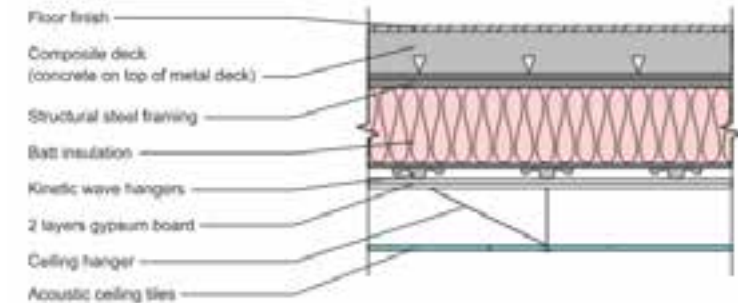
WALLS: Light Frame Wood Walls & CLT Elevator Walls



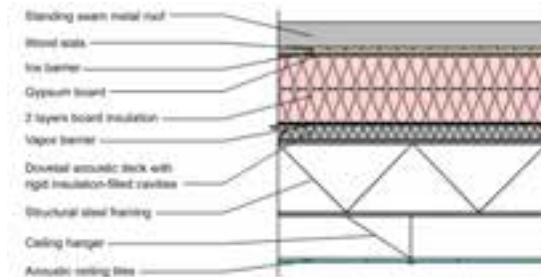
STEEL (DESIGN OPTION)



FLOOR: Concrete on Metal Deck, WF Beams



ROOF: Metal Deck, Steel Bar Joists, WF Beams



WALLS: CFS Stud Walls & CMU Elevator Walls

Office / Retail

Type III-B over IA Construction, IBC 2015

150,000 ft² (14,000 m²)

7 STORY

Foundations, P2: Concrete Mat Slab Foundation

P1, L1: Concrete Slabs

L2: Concrete Podium Slab

L3 - Roof: CLT Panel & Glulam

Lateral: Concrete Cores

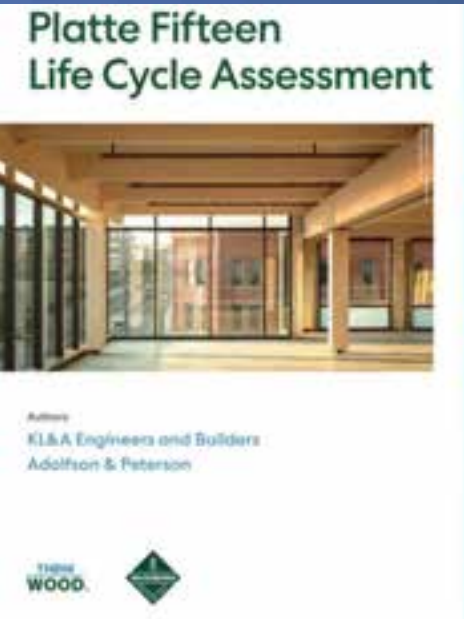
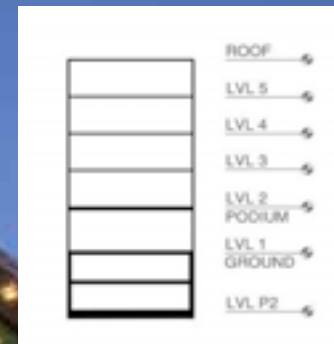
Grid: 30' x 30'

Owner: Crescent

Architect: OZ

Engineer: KL&A

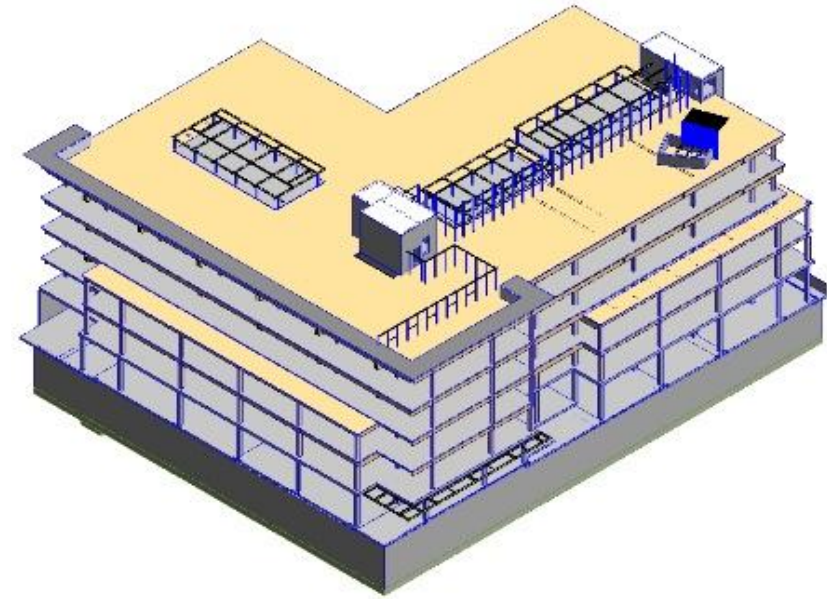
Contractor: Adolfson & Peterson



PLATTE FIFTEEN

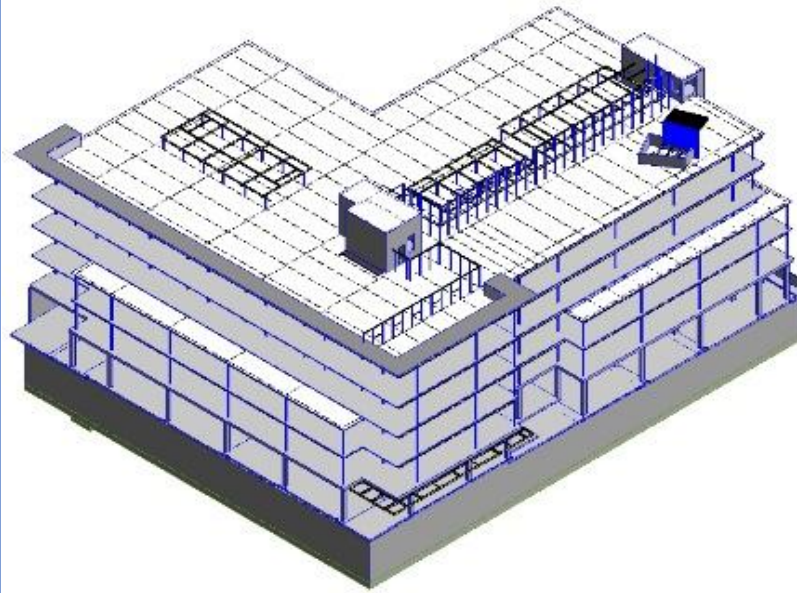
Denver, Colorado

- FLOOR: 3ply CLT Floor, Concrete Topping Slab, Glulam Framing



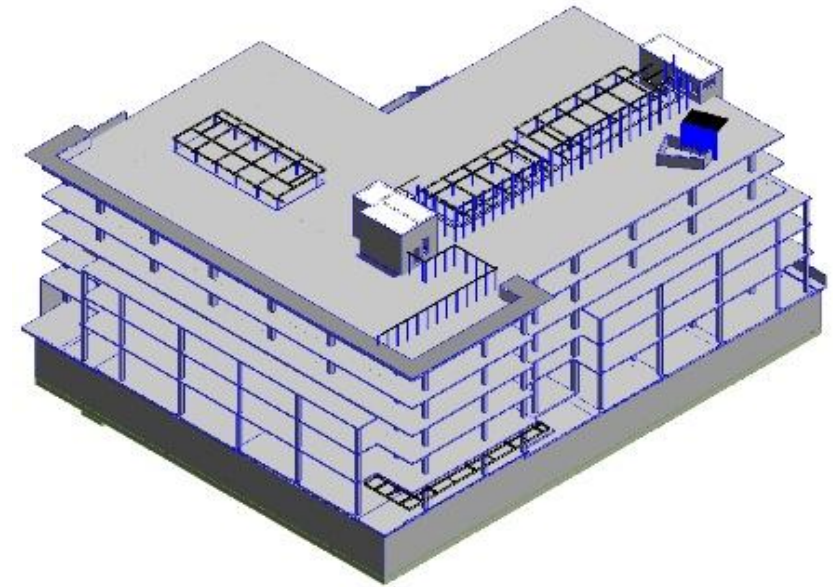
MASS TIMBER
(AS CONSTRUCTED, 2019)

- FLOOR: Concrete on Metal Deck, WF Framing



STEEL

- FLOOR: Post Tensioned Concrete Slabs, Concrete Columns



PT CONCRETE

RTF

Multifamily / Retail

Type IV-B Construction

139,000 ft² (12,900 m²)

12 Story

BURWELL

Office / Higher Ed

Type III-B Construction

22,990 ft² (2,136 m²)

3 Story

NEZ PERCE

Office

Type V-B Construction

16,045 ft² (1,491 m²)

2 Story

STUDY TRENDS

DENVER OFFICE

Office / Higher Ed

Type III-A Construction

98,280 ft² (9,130 m²)

4 Story

P15

Office / Retail

Type III-B over IA Construction

150,000 ft² (14,000 m²)

7 Story

RTF



12 Story

Foundations: Drilled Piers

No below grade

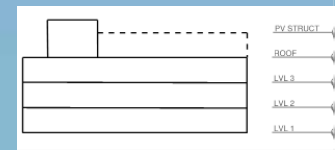
L1: Concrete SOG

L2-L4: Concrete Slabs

L5 - Roof: CLT Panel & Glulam

Lateral: Concrete Cores

BURWELL



3 Story

Foundations: Drilled Piers

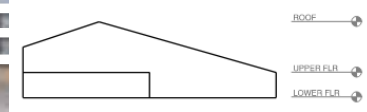
No below grade

L1: Concrete SOG

L2 - Roof: CLT Panel & Glulam

Lateral: CLT Panel Walls at Core

NEZ PERCE



2 Story

Foundations: Spread Footings

Partial below grade

L1: Concrete SOG

L2: Light Frame Wood & Glulam

Roof: CLT Panel & Glulam

CLT Elevator Walls

Lateral: Light Frame Wood Shear Walls

DENVER OFFICE

4 Story

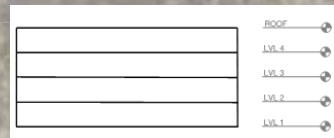
Foundations: Spread Footings

No below grade

L1: Concrete SOG

L2 - Roof: CLT Panel & Glulam

Lateral: Precast Conc Core Walls + Glulam Brace



P15

7 Story

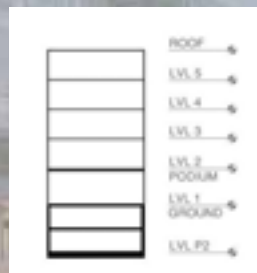
Foundations, P2: Concrete Mat Slab

P1, L1: Concrete Slabs

L2: Concrete Podium Slab

L3 - Roof: CLT Panel & Glulam

Lateral: Concrete Cores



AVERAGE

1% \$ PREMIUM

~

31% GWP
SAVINGS

~60 HOMES
ELECTRICITY FOR
1 YEAR

AVERAGE

16% SCHEDULE
SAVINGS

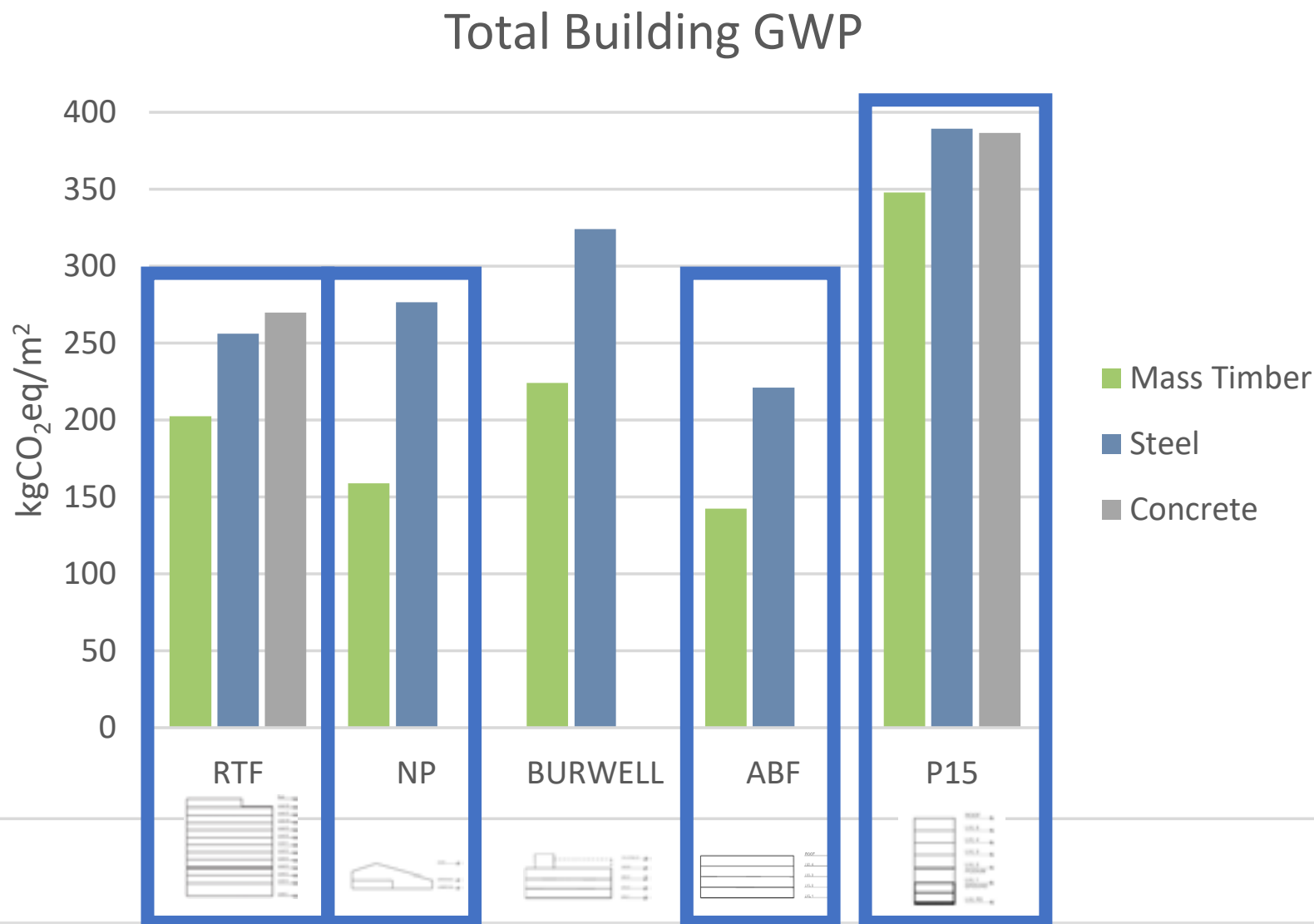


GWP vs COST vs SCHEDULE

10% – 43%
Total
Reduction

47% – 75%
Superstructure
Reduction

63% – 118%
Superstructure
Structure
Reduction

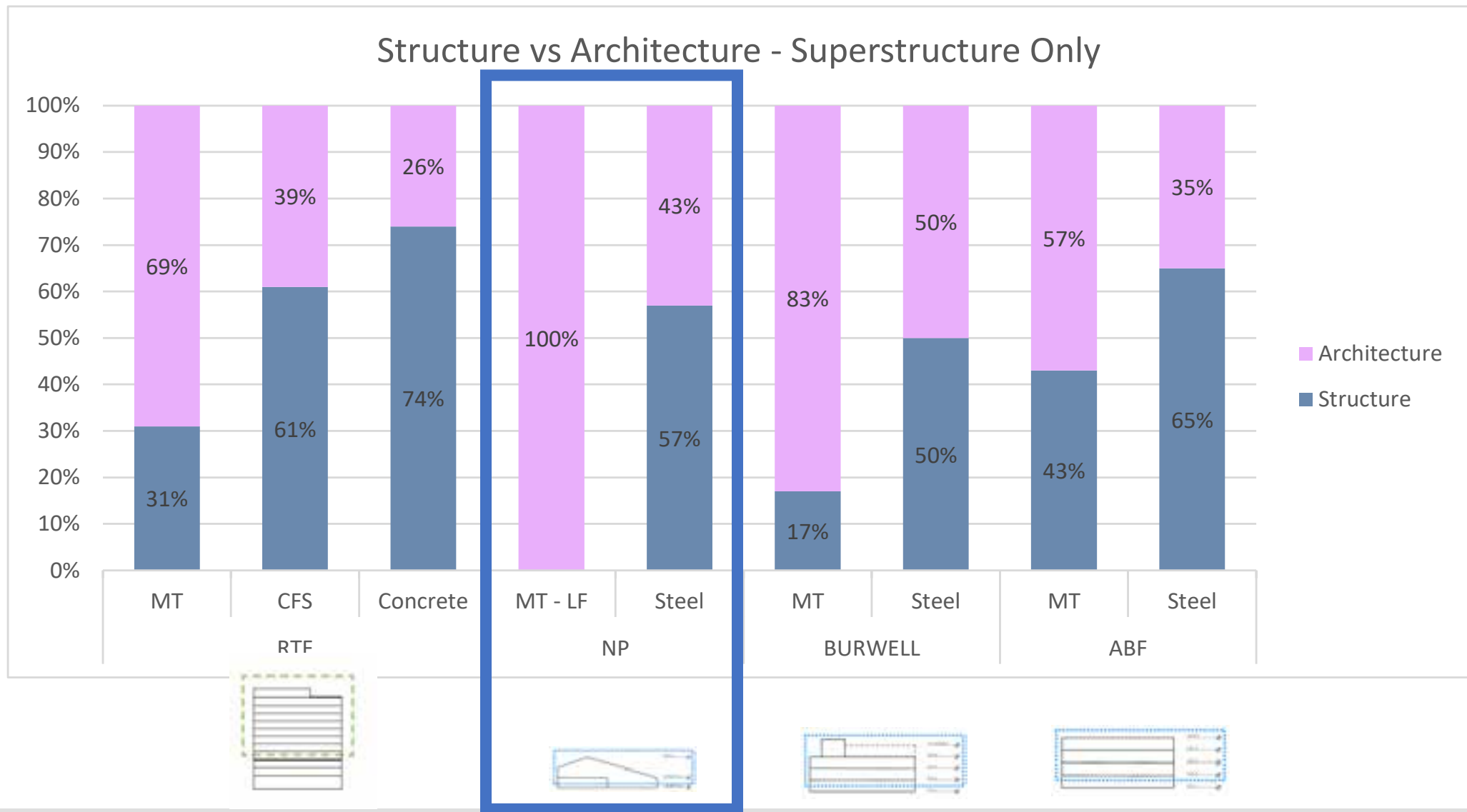


AVERAGE

MT
182 kgCO₂eq/m²

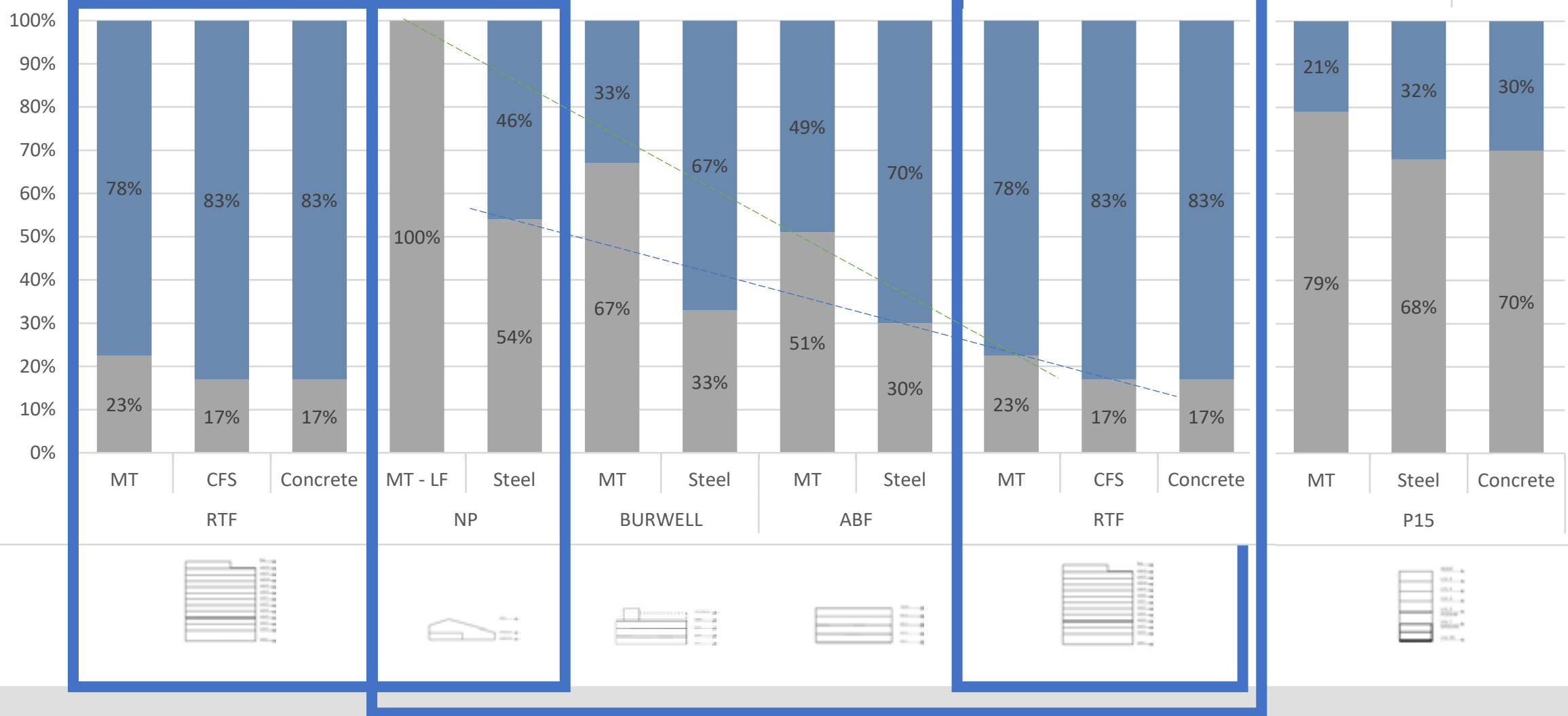
STEEL
273 kgCO₂eq/m²

TOTAL BUILDING GWP



STRUCTURE vs ARCHITECTURE

Substructure vs Superstructure GWP - Structure Only

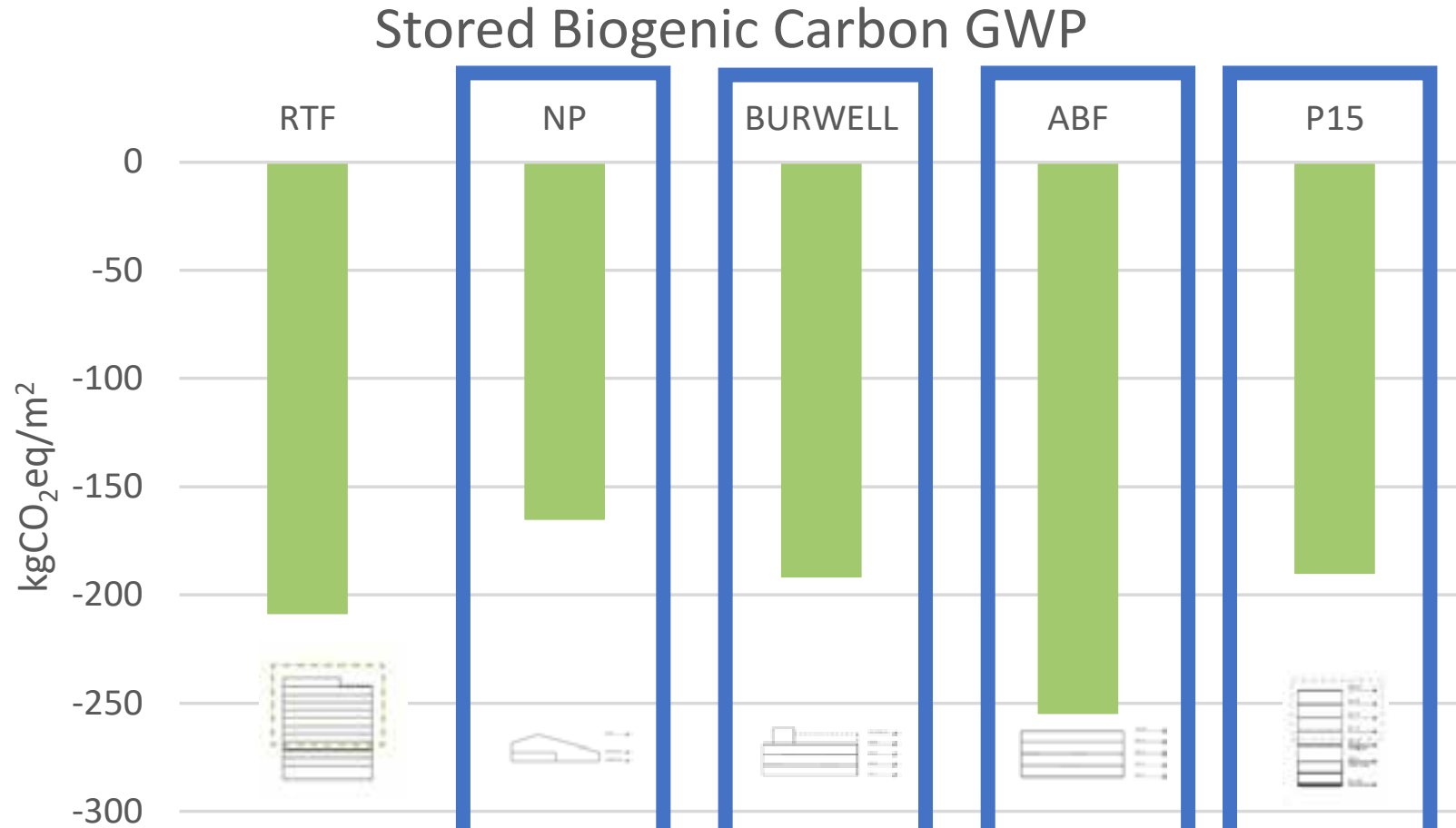


SUBSTRUCTURE vs SUPERSTRUCTURE

-165 to -255
kgCO₂eq/m²

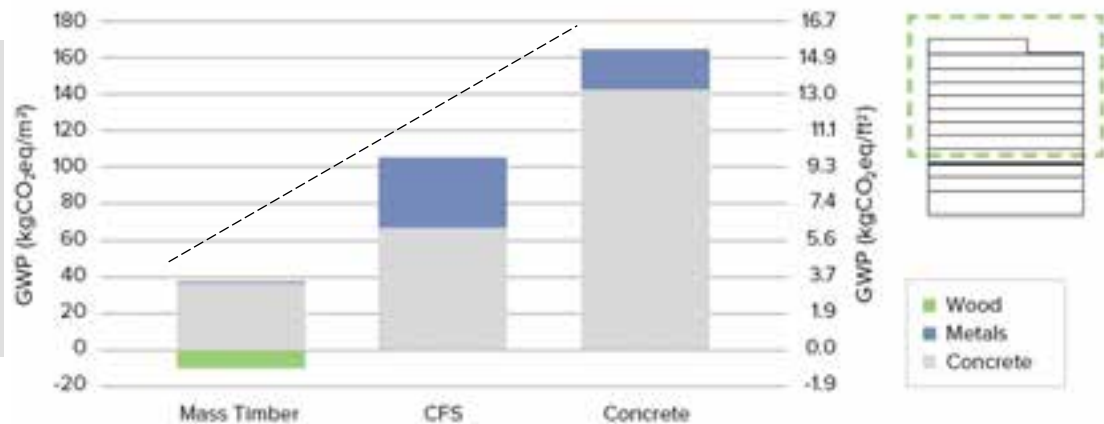
~ GWP of
186,000 ft² (17,300 m²)
NEW CONSTRUCTION

~580 FLIGHTS
ROUND TRIP
PDX to LONDON

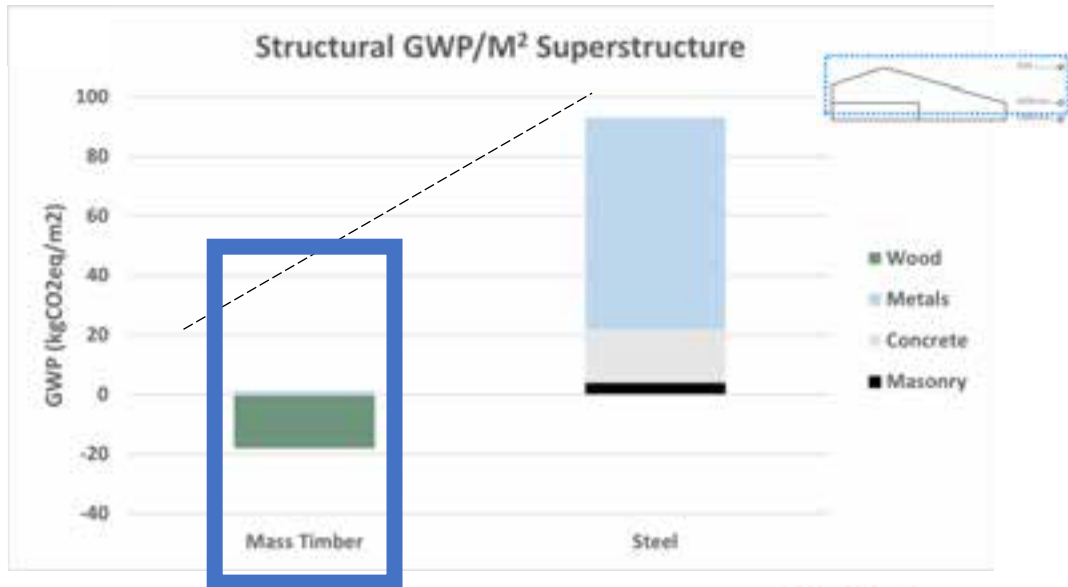


BIOGENIC CARBON

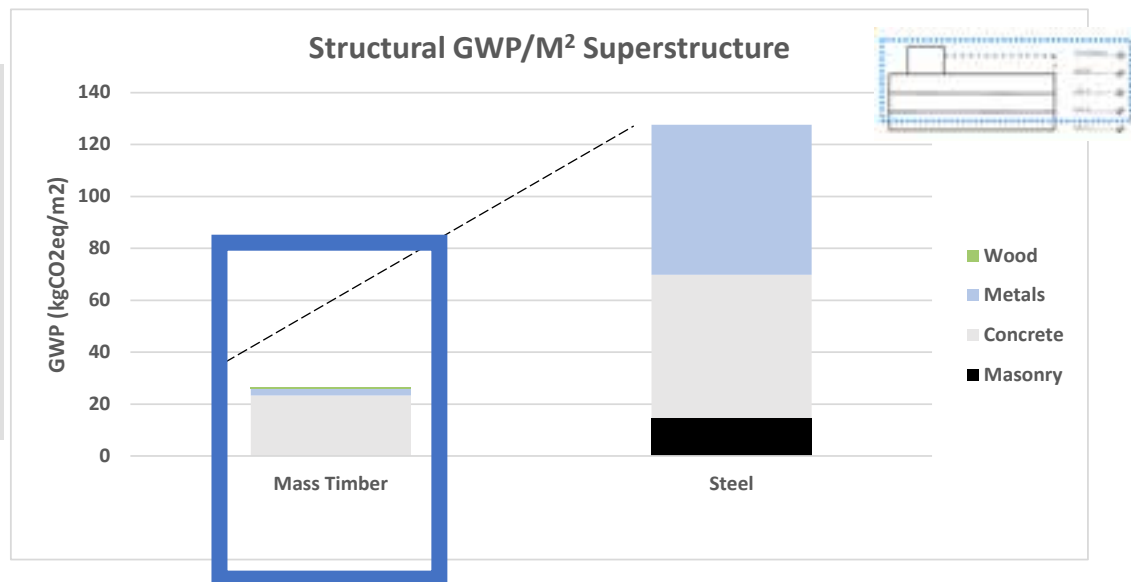
RTF



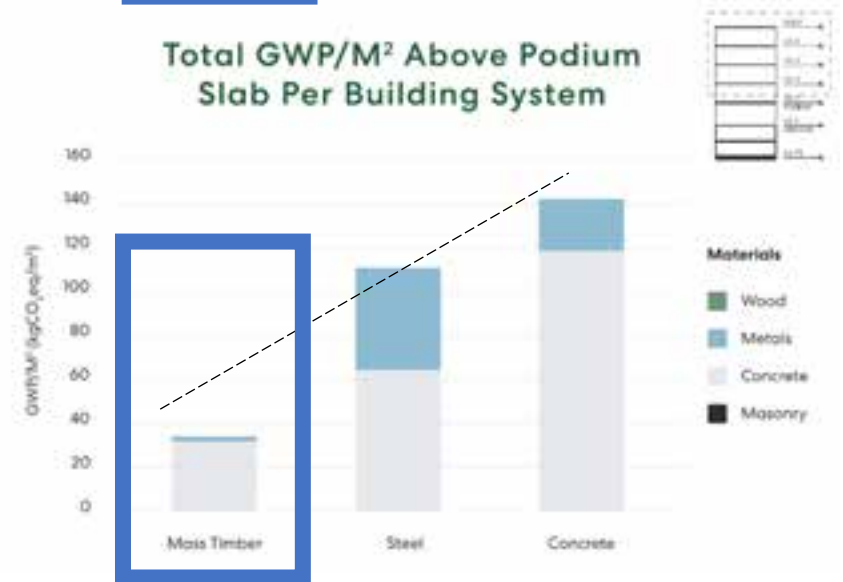
NP



BURWELL



P15



ALTERNATE STRUCTURAL SYSTEMS

- **MASS TIMBER STRUCTURAL SYSTEMS HAVE CLEAR EMBODIED CARBON BENEFITS (SOURCE RESPONSIBLY & STAY INFORMED)**
- **GWP vs COST BALANCE**
- **SPEED OF CONSTRUCTION**
- **RESPECT STORED BIOGENIC CARBON**
- **DESIGN FOR DECONSTRUCTION & EASE RECOVERY**
- **EMBODIED CARBON AT CONCEPT DESIGN**





THANK YOU

This concludes The American Institute of Architects Continuing Education Systems Course.

Robbie Camann, PE Principal and Embodied Carbon Operations Director

rcamann@klaa.com



Photo Credit: JC Buck