TRACKING CARBON THROUGH DESIGN:

FROM EARLY-STAGE CARBON ACCOUNTING TO WHOLE BUILDING LIFE CYCLE ASSESSMENT

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KL&A Engineers & Builders

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.

Photo Credit: JC Buck

MEASURE, REPORT, AND REDUCE:

USING COMPARATIVE LCA TO HIGHLIGHT THE EMBODIED CARBON BENEFITS OF WOOD CONSTRUCTION

KL&A
Engineers & Builders

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

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Photo Credit: JC Buck

- PLATTE FIFTEEN LCA CASE STUDY
- RETURN TO FORM LCA CASE STUDY
- CONCEPTUAL DESIGN EMBODIED CARBON QUANTIFICATION

OUTLINE

Photo by Aleksandar Radovanovic on Unsplash

CRADLE TO GATE

CRADLE TO GRAVE

Life Cycle Stages & Study Scope

Product			Constr-uction		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	**Transport**	**Manufacturing**	**Transport**	*Construction\Installation*	Use	**Maintenance**	**Repair**	**Replacement**	**Refurbishment**	***Operational Energy Use***	Operational Water Use	Deconstruction	**Transport**	**Waste Processing**	**Disposal**	**Reuse**	**Recycling**	**Energy Recovery**
✓	✓	✓	✓			✓	✓	✓	✓				✓	✓	✓	✓	✓	✓

Figure 3. Life Cycle Stages[3] 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

PLATTE FIFTEEN

Denver, Colorado

Office / Retail

Type III-B over IA Construction, IBC 2015

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- P1, L1: Concrete Slabs
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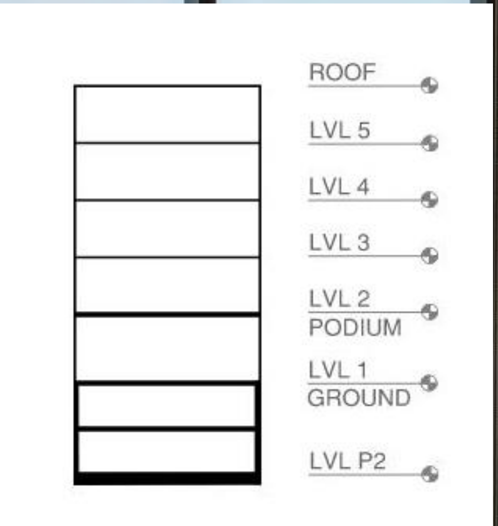
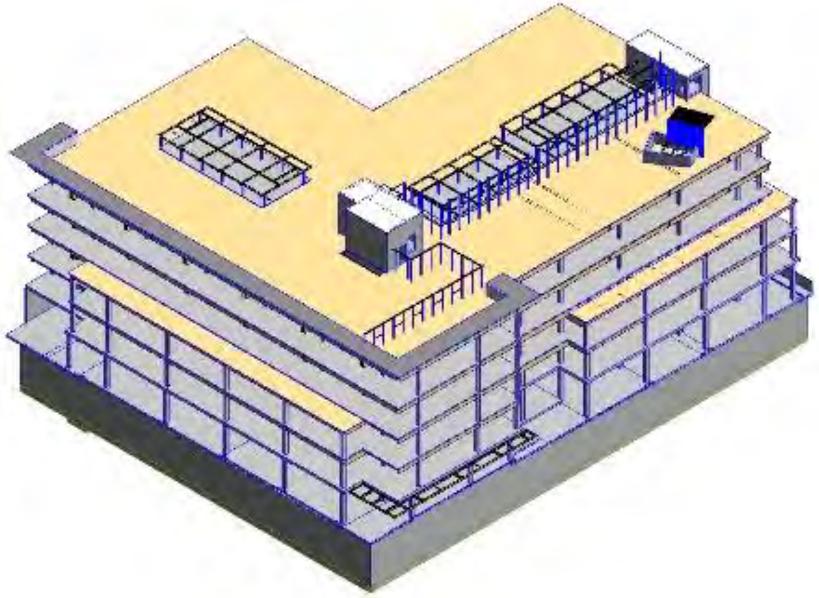
30’ x 30’ Grid



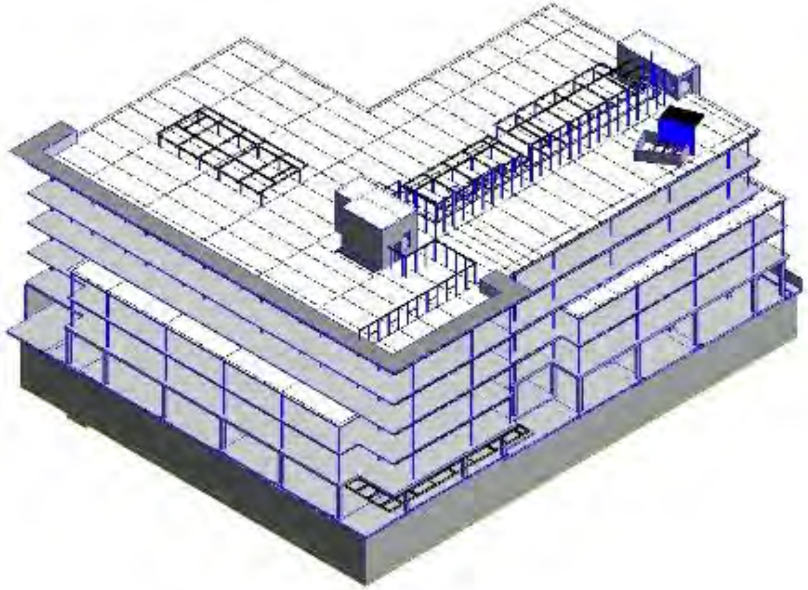
PLATTE FIFTEEN

Denver, Colorado

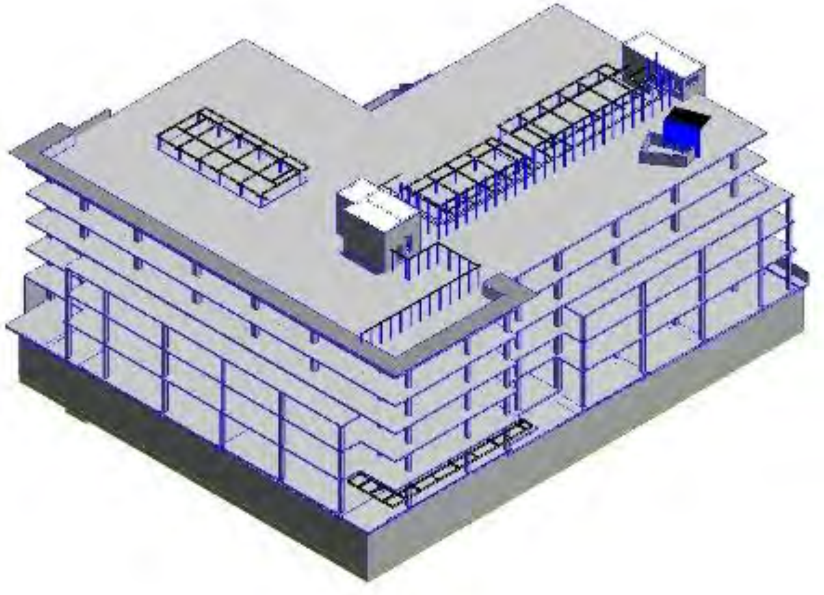
Photo Credit: JC Buck



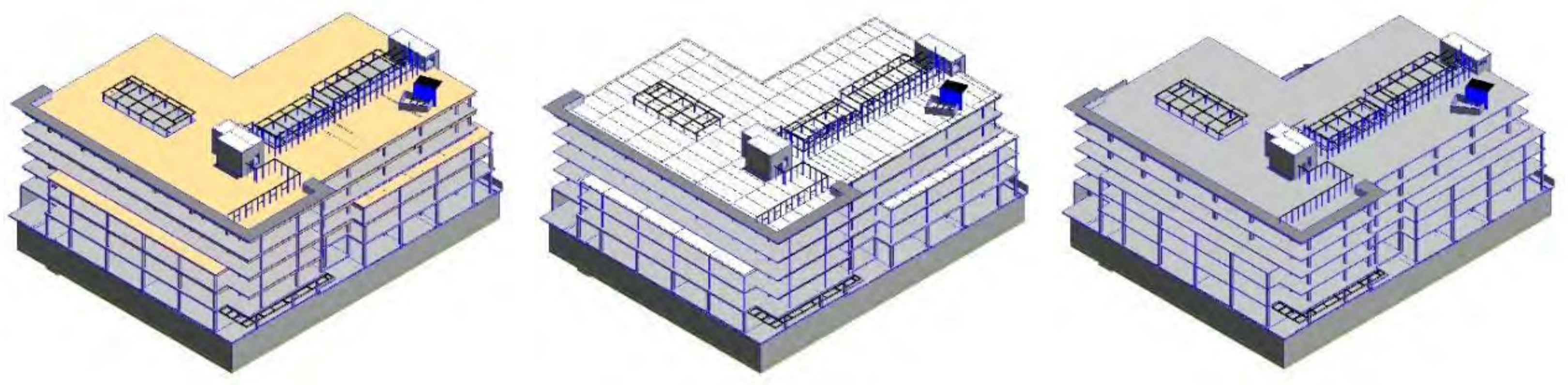
MASS TIMBER
(AS CONSTRUCTED)



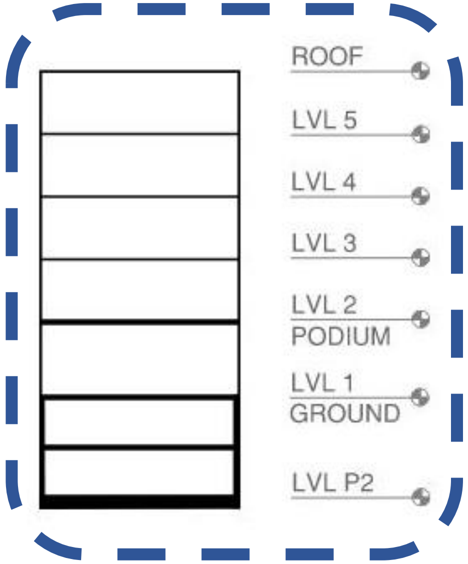
STEEL

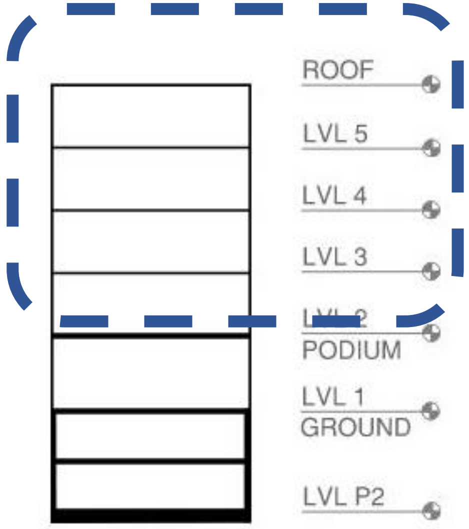


PT CONCRETE

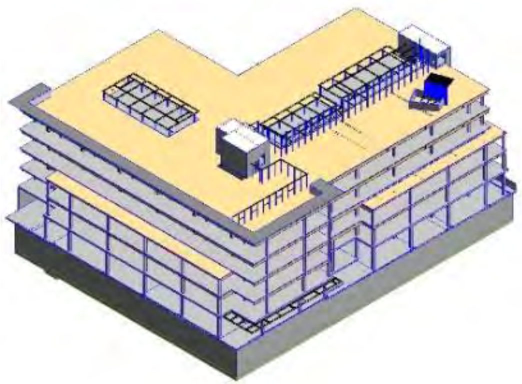


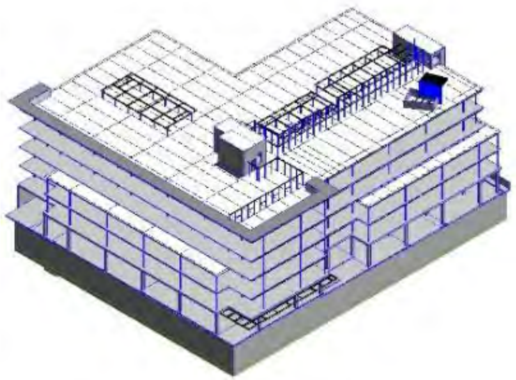
The GWP is overwhelmingly dominated by this piece

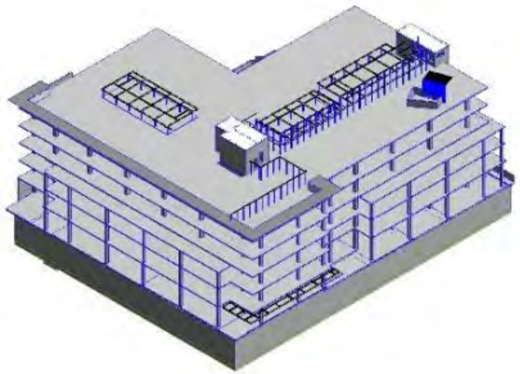




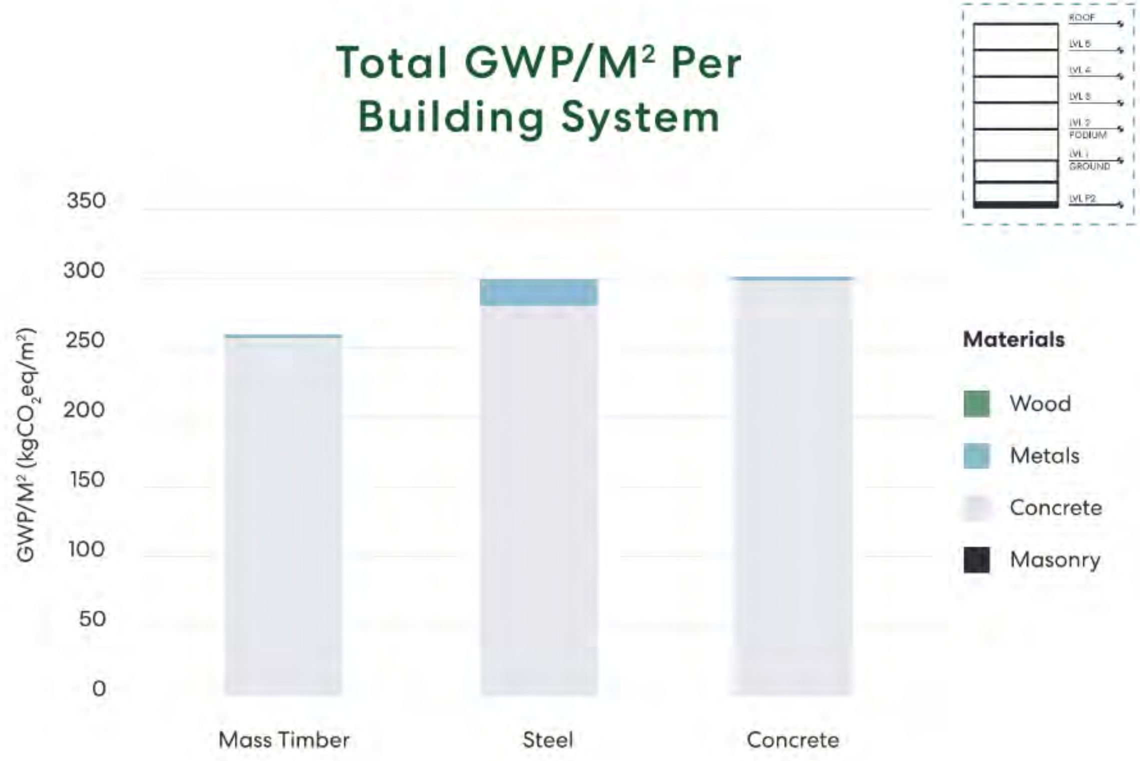
Floor assembly, (including topping) framing, columns



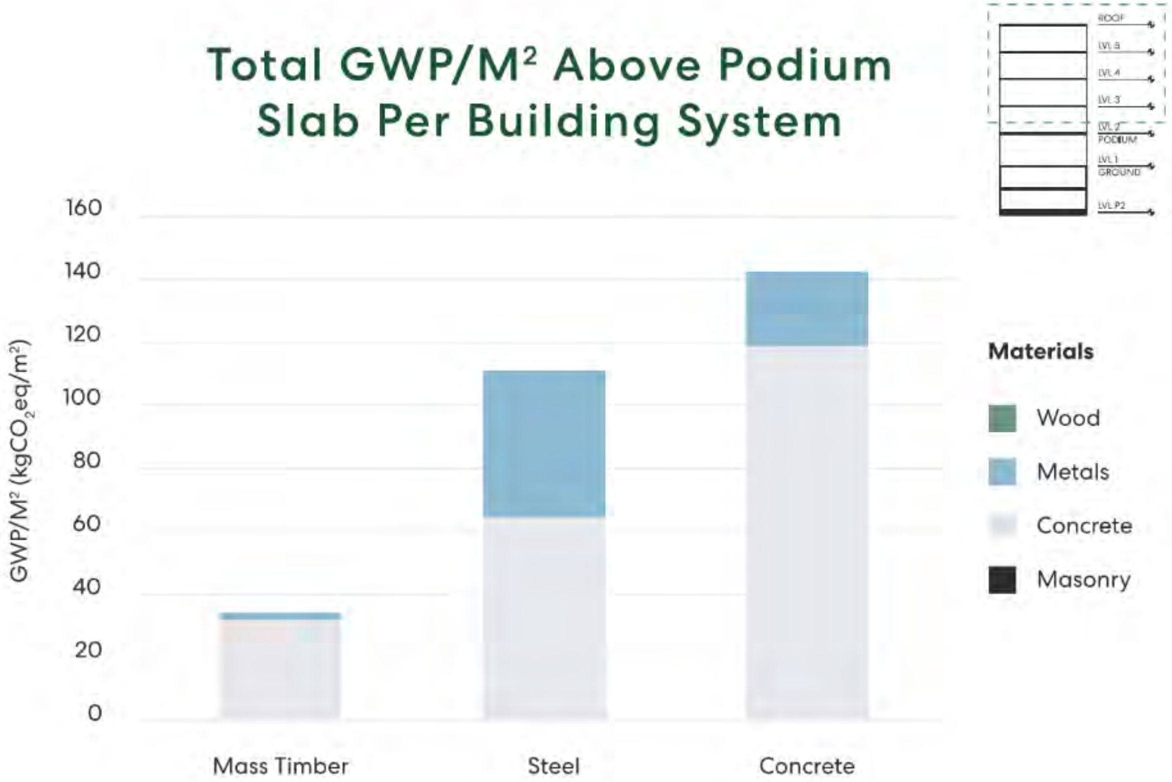


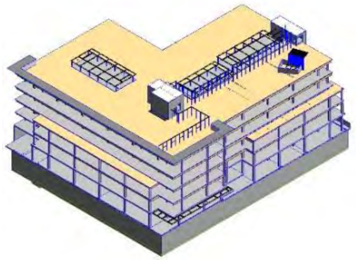


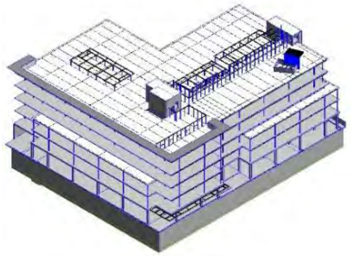
Total GWP/M² Per Building System

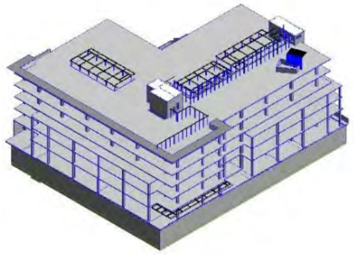


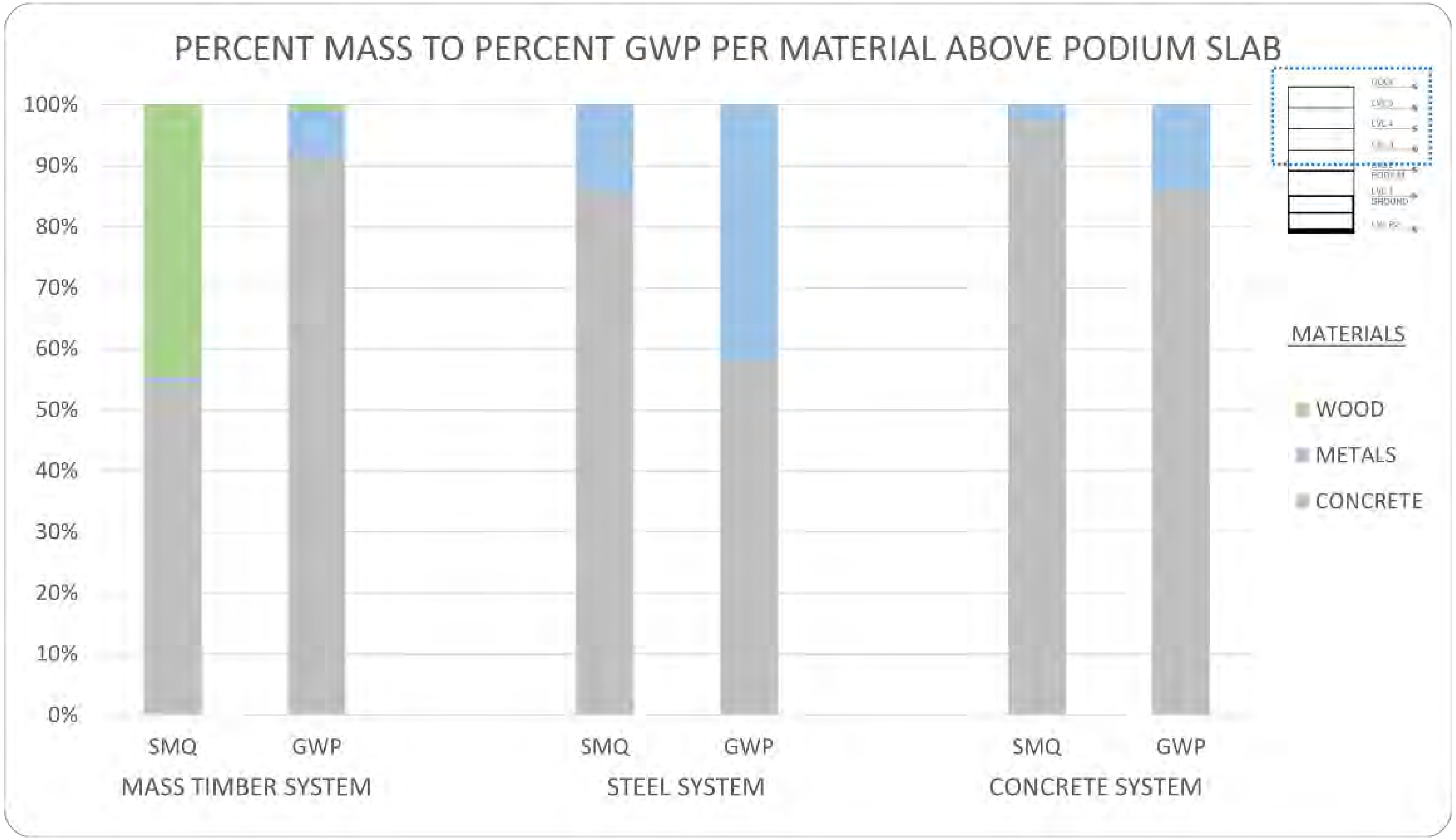
Total GWP/M² Above Podium Slab Per Building System

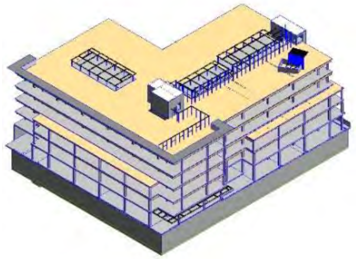


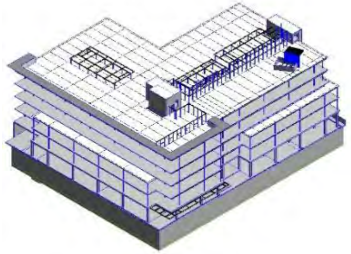


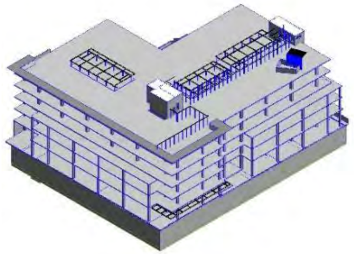




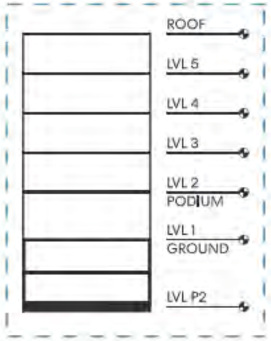

PERCENT MASS TO PERCENT GWP PER MATERIAL ABOVE PODIUM SLAB
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
SMQ
GWP
SMQ
GWP
SMQ
GWP
MASS TIMBER SYSTEM
STEEL SYSTEM
CONCRETE SYSTEM
MATERIALS
WOOD
METALS
CONCRETE

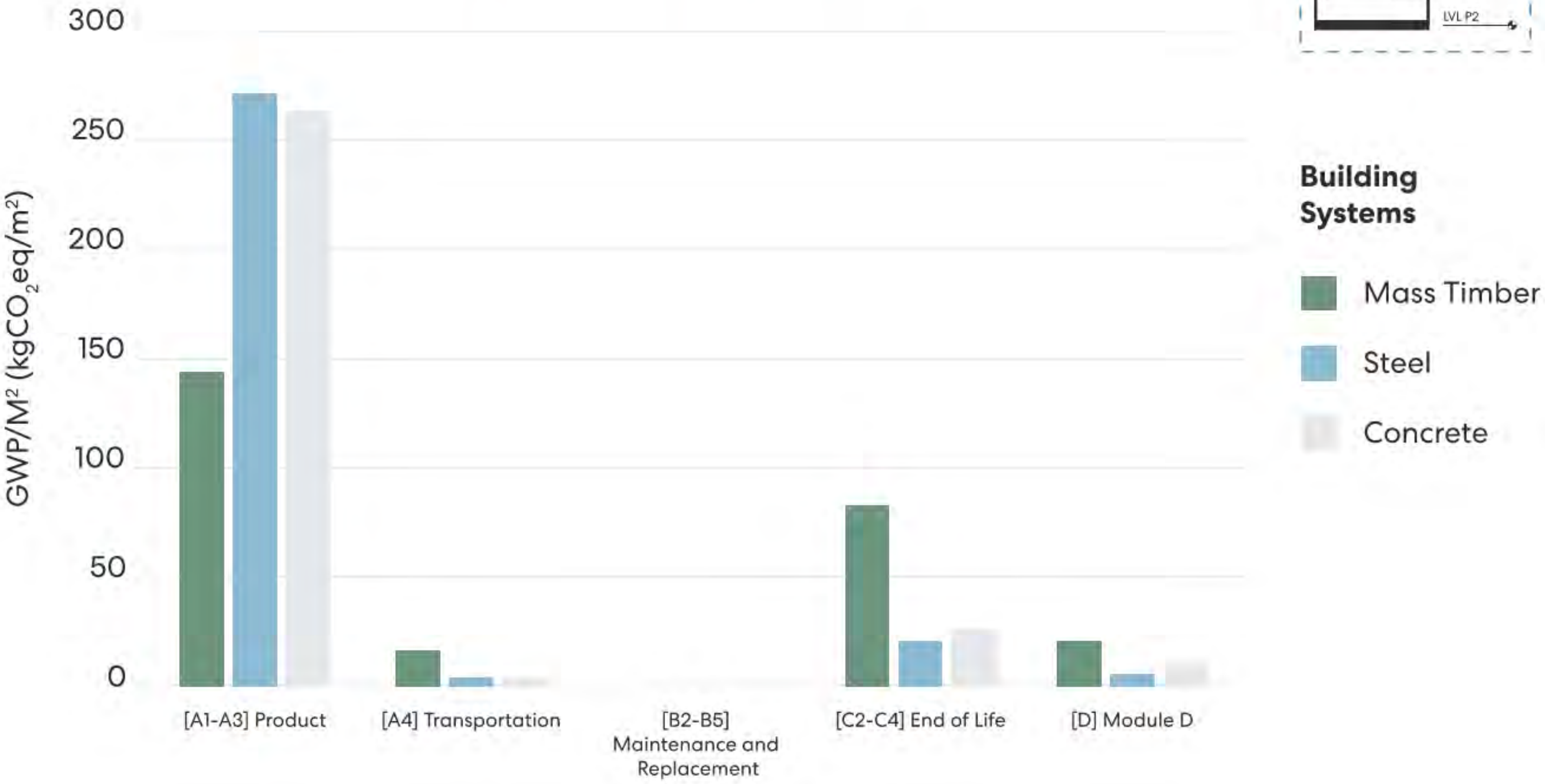


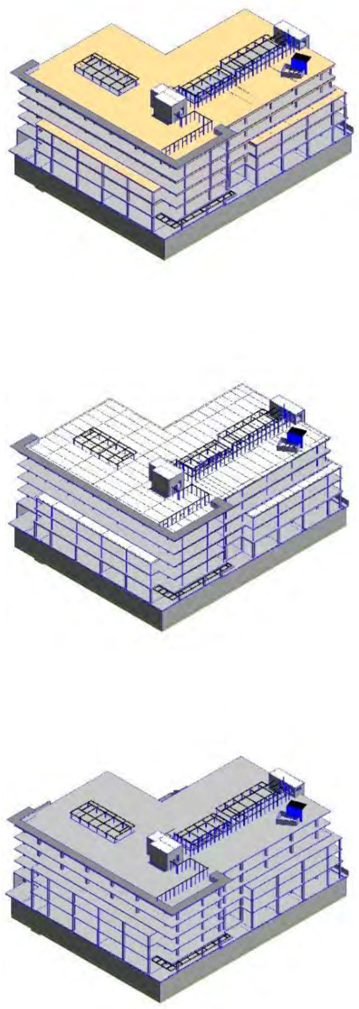




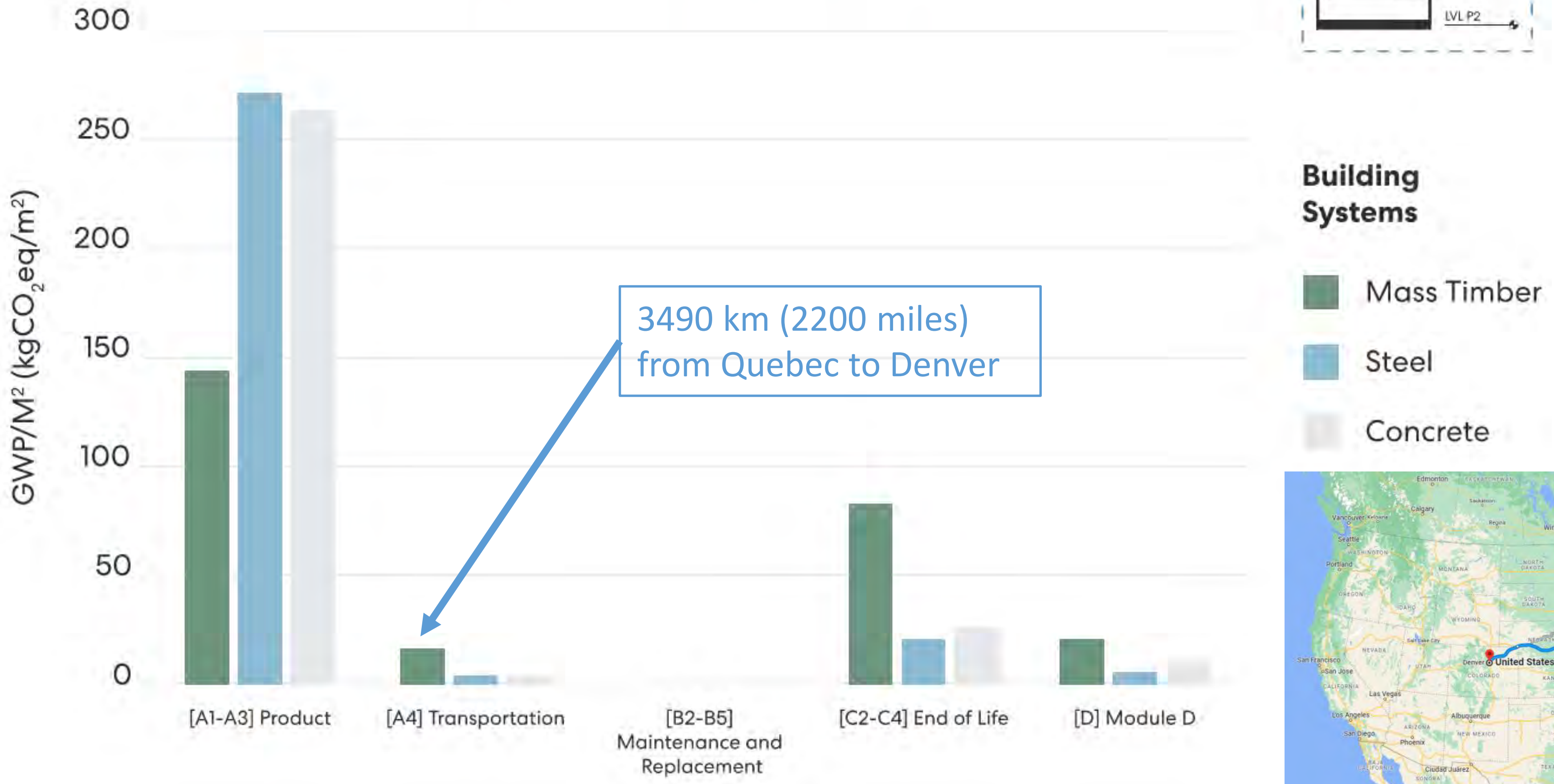
Total GWP/M² Per Life Cycle Stage

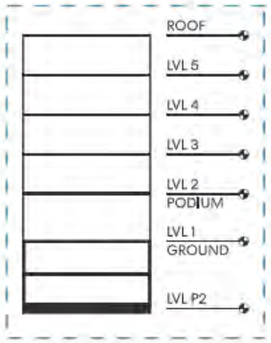


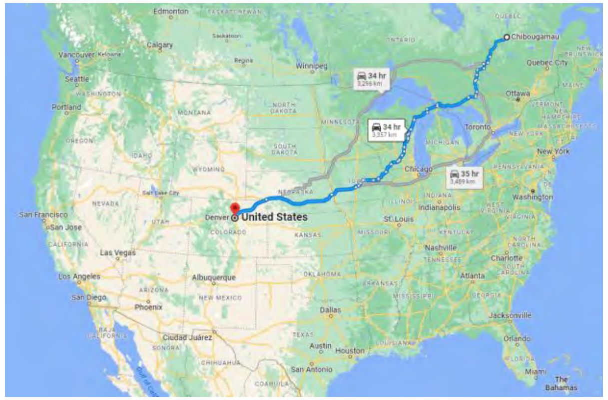


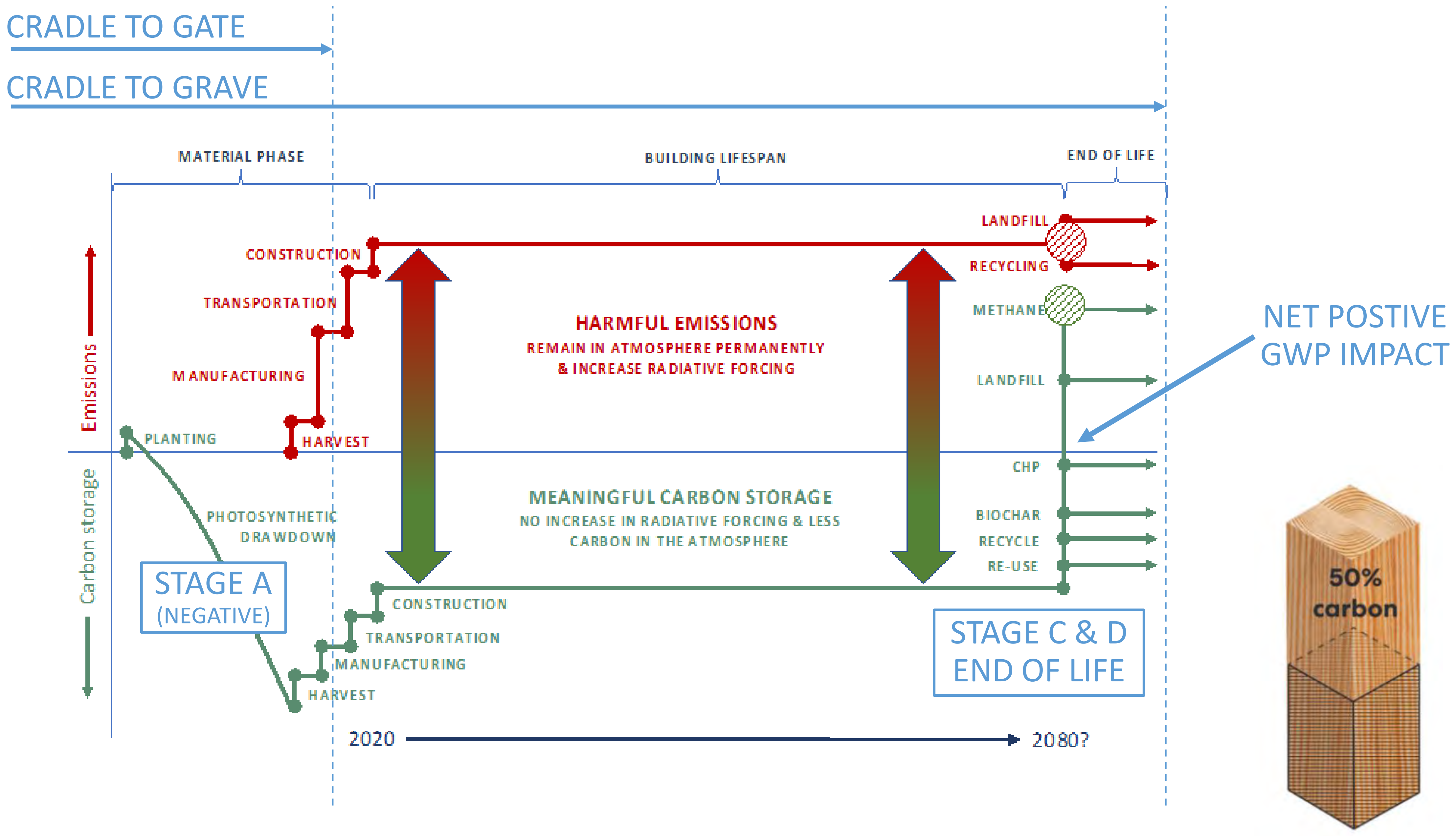


Total GWP/M² Per Life Cycle Stage

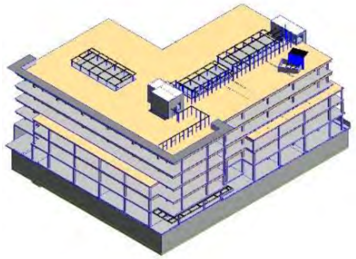


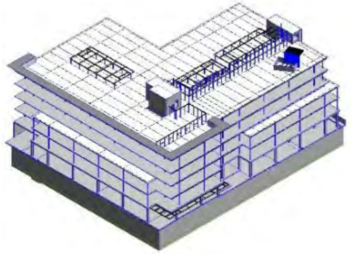


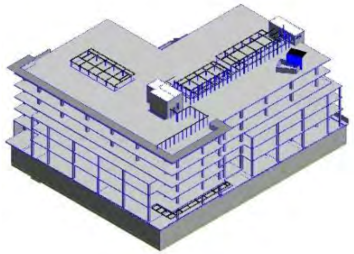




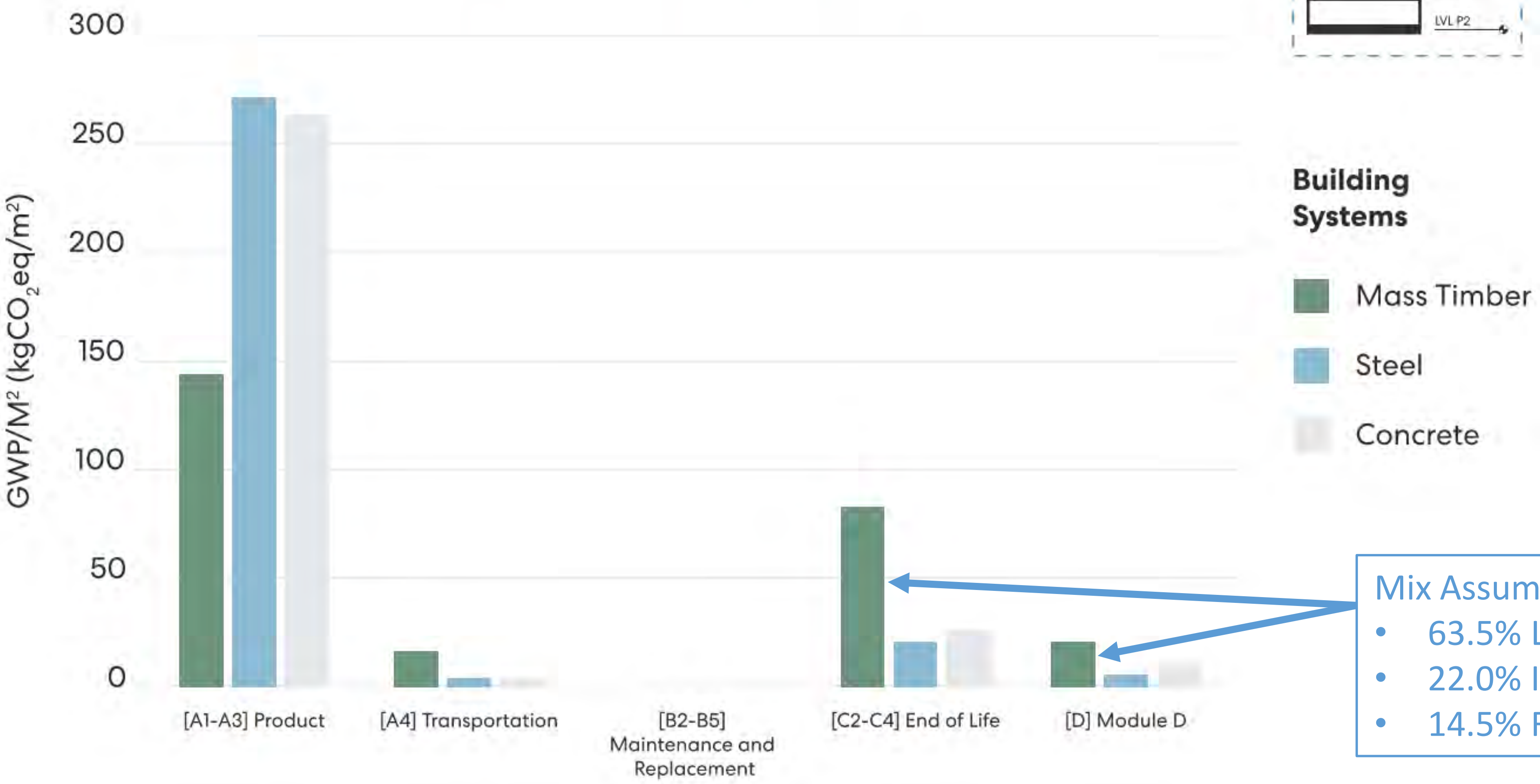
CRADLE TO GATE
CRADLE TO GRAVE
MATERIAL PHASE
BUILDING LIFESPAN
END OF LIFE
Emissions
Carbon storage
CONSTRUCTION
TRANSPORTATION
MANUFACTURING
PLANTING
HARVEST
PHOTOSYNTHETIC DRAWDOWN
STAGE A (NEGATIVE)
HARMFUL EMISSIONS
REMAIN IN ATMOSPHERE PERMANENTLY & INCREASE RADIATIVE FORCING
MEANINGFUL CARBON STORAGE
NO INCREASE IN RADIATIVE FORCING & LESS CARBON IN THE ATMOSPHERE
CONSTRUCTION
TRANSPORTATION
MANUFACTURING
HARVEST
LANDFILL
RECYCLING
METHANE
LANDFILL
CHP
BIOCHAR
RECYCLE
RE-USE
NET POSTIVE GWP IMPACT
STAGE C & D END OF LIFE
2020
2080?
50% carbon

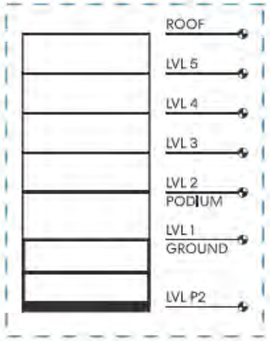






Total GWP/M² Per Life Cycle Stage





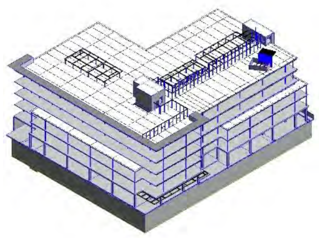
Mix Assumptions for Wood:

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

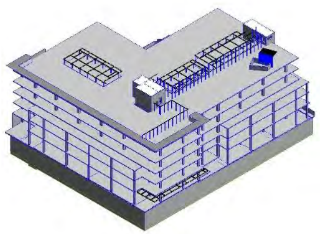
DOLLAR COST
vs
TIME COST
vs
CARBON COST

Photo by Michele dot com on Unsplash

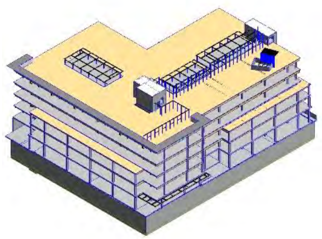
DOLLAR COST



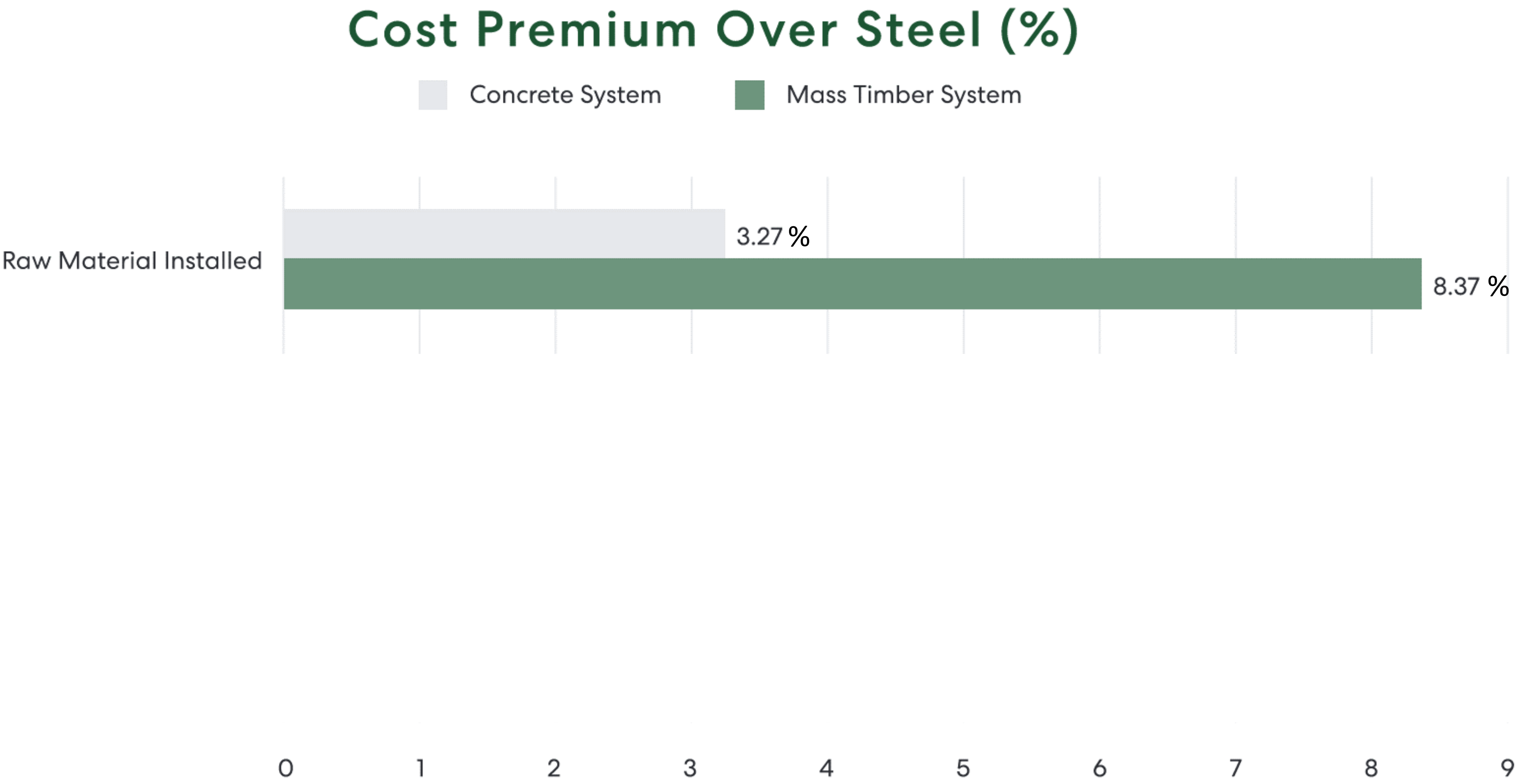
Steel: Lowest = Baseline



Concrete: Middle



Mass Timber: Highest



PLATTE FIFTEEN

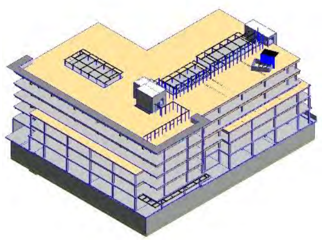
TIMELAPSE

MT CONSTRUCTION SPEED:

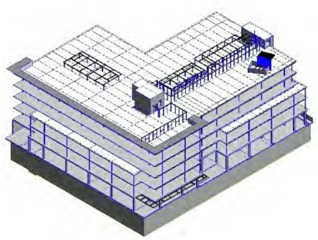
2,000 SF / DAY

6-8 WORKERS

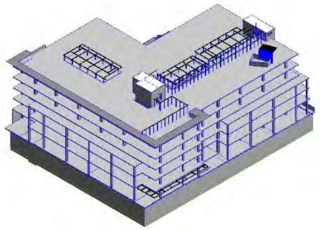
DOLLAR COST & TIME COST



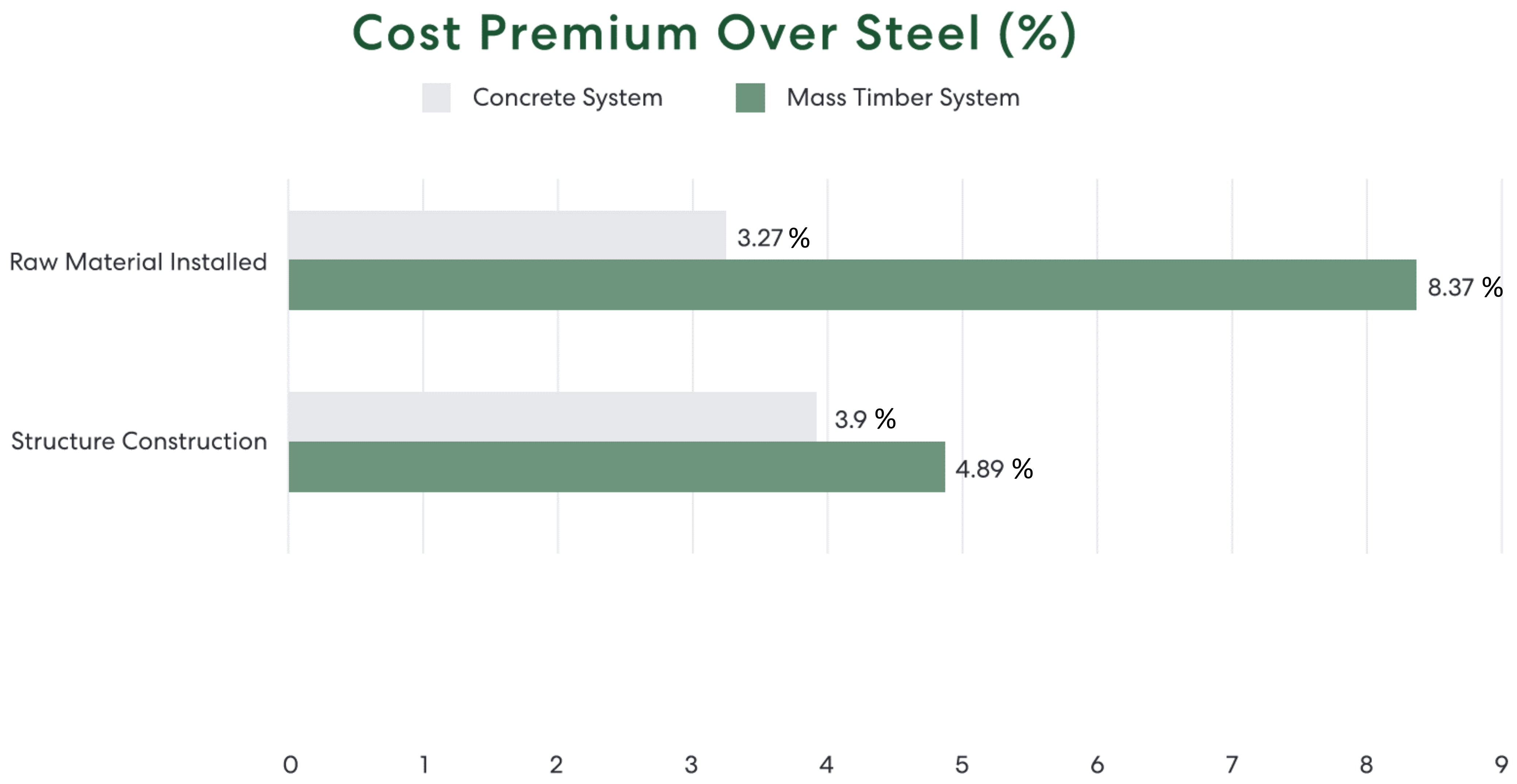
Mass Timber:
Baseline time



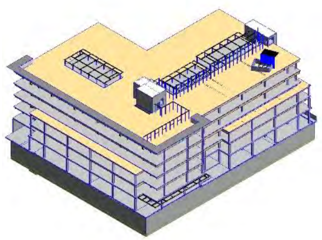
Steel:
+ 2 months



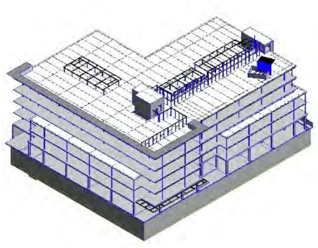
Concrete:
+ 3.5 months



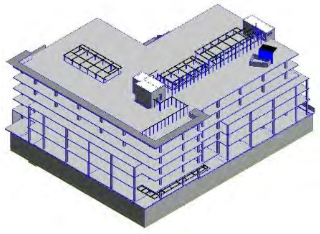
DOLLAR COST & TIME COST



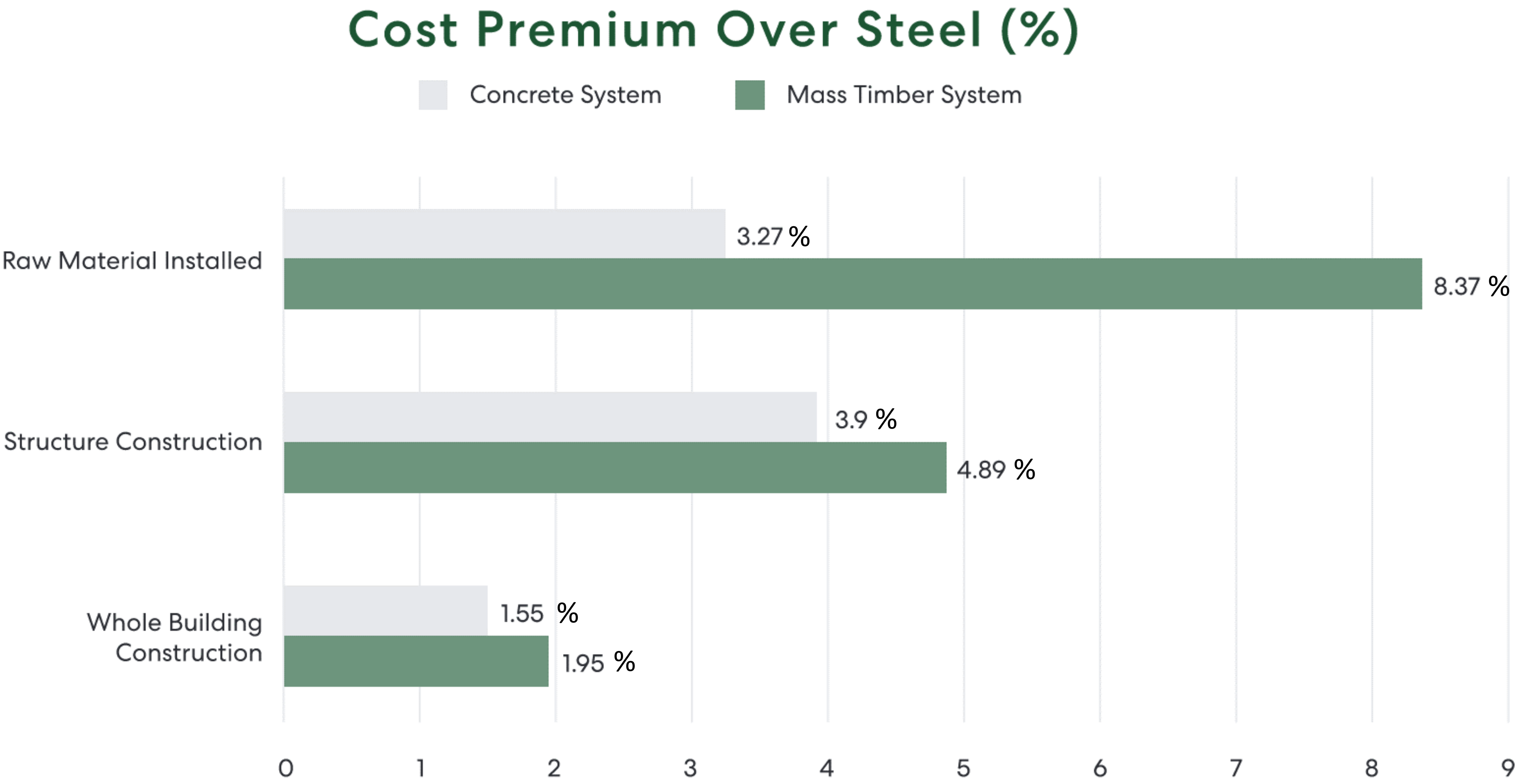
Mass Timber:
Baseline time



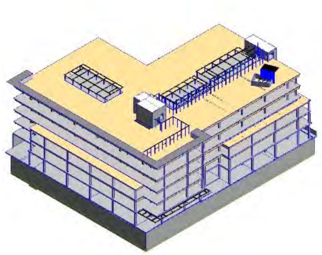
Steel:
+ 2 months



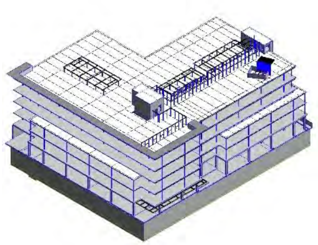
Concrete:
+ 3.5 months



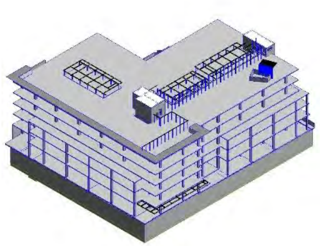
DOLLAR COST vs CARBON COST



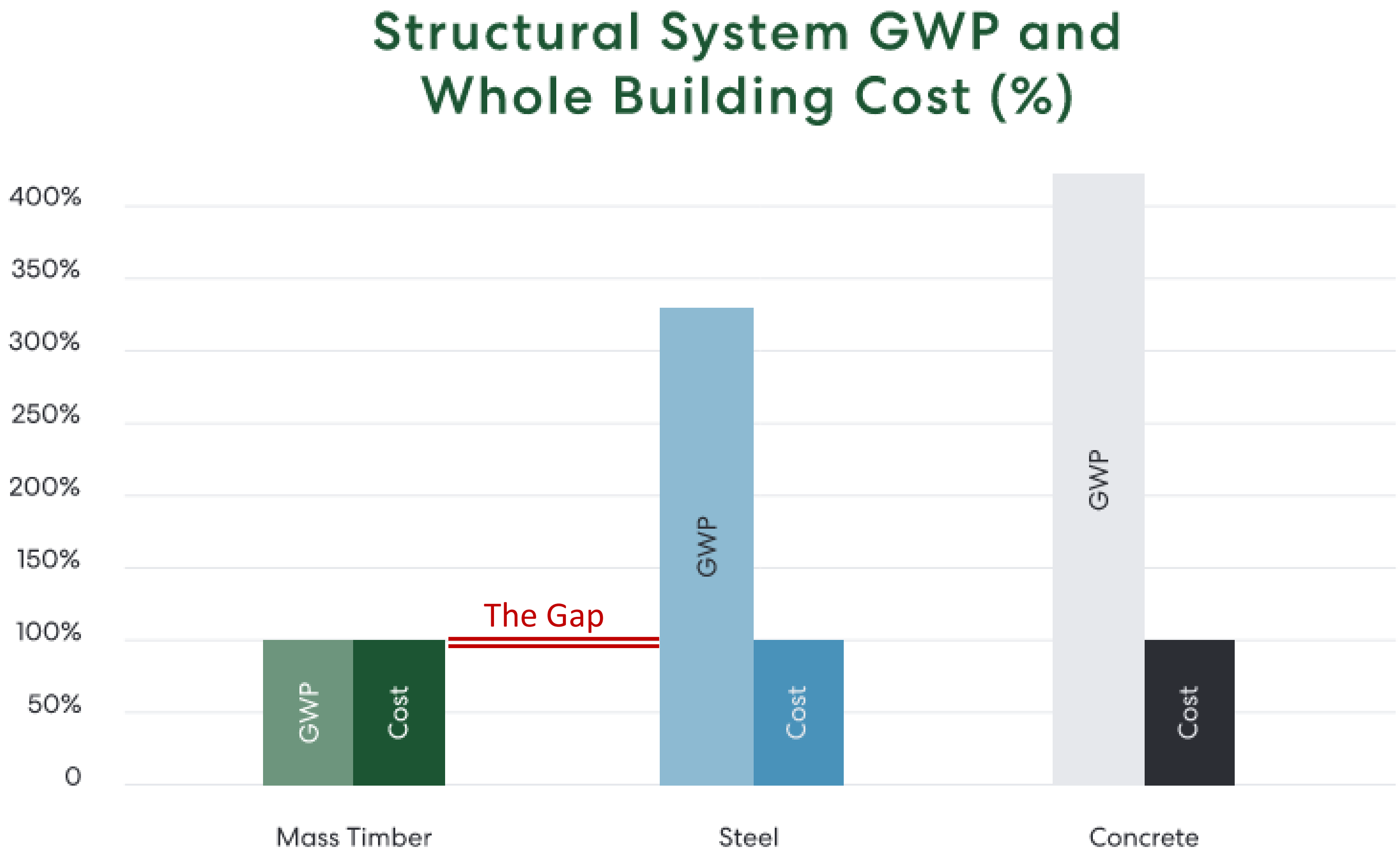
Mass Timber: Baseline

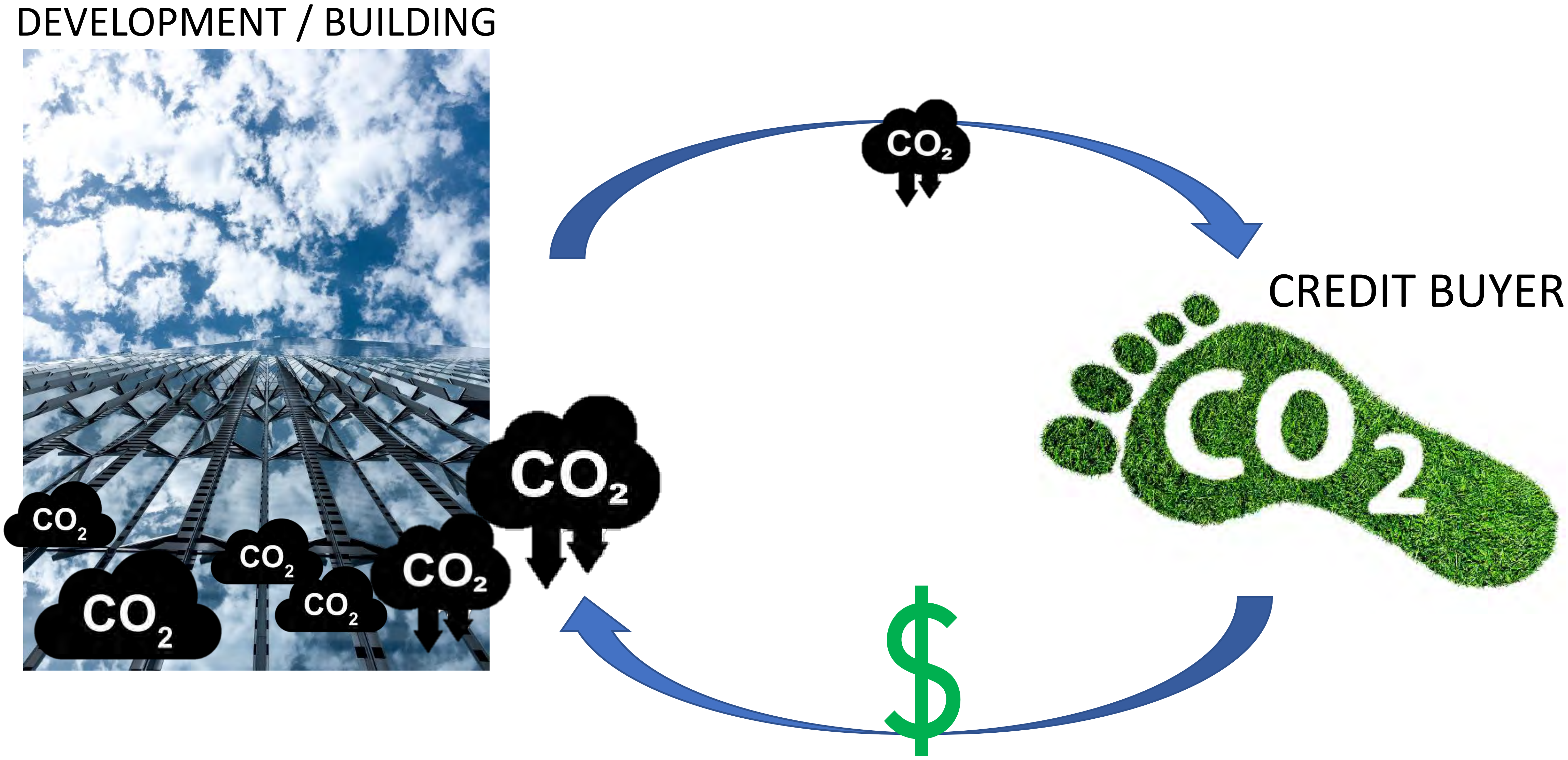


Steel

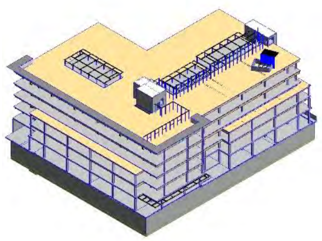


Concrete

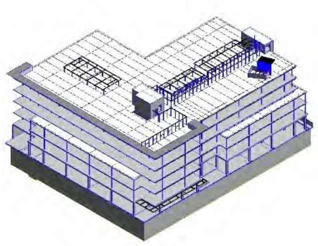



DEVELOPMENT / BUILDING
CO2
CO2
CO2
CO2
CO2
CO2
CO2
CREDIT BUYER
CO2
$

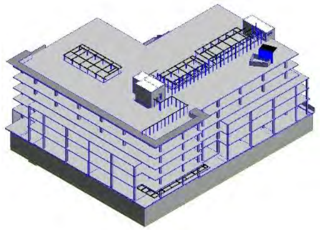
DOLLAR COST & CARBON COST



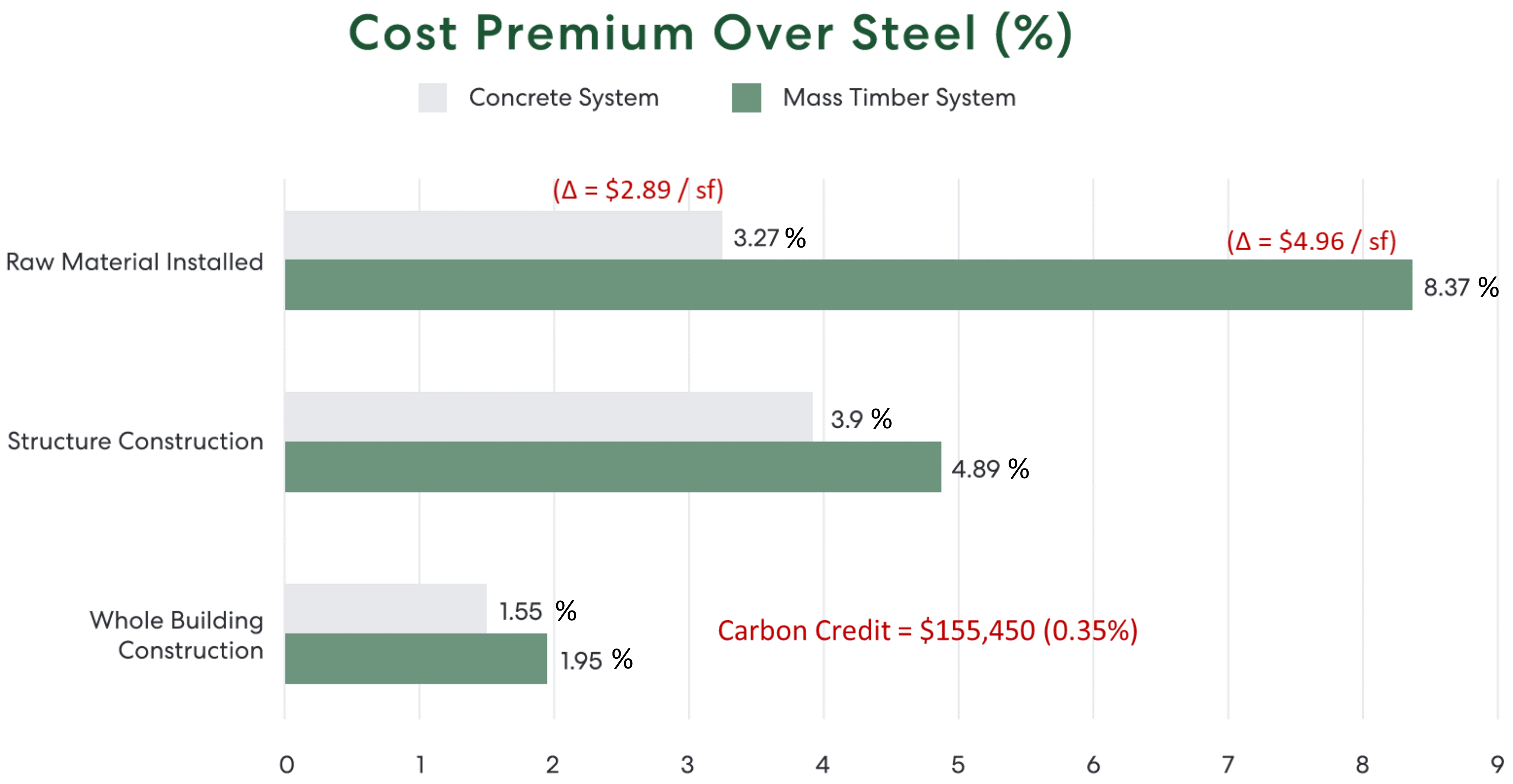
Mass Timber:
Baseline time



Steel:
+ 2 months



Concrete:
+ 3.5 months



CASE STUDY SERIES

USDA, SLB, WW, THINKWOOD, KL&A

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
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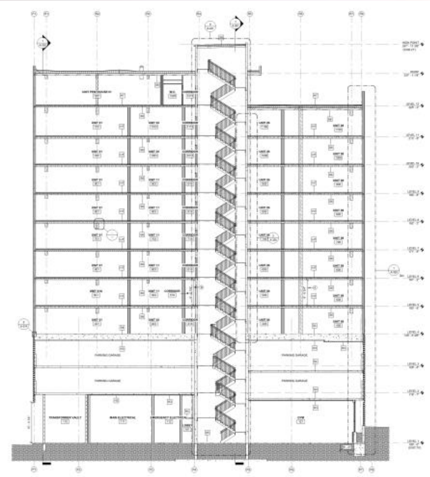
- L5 - Roof: Mass Timber

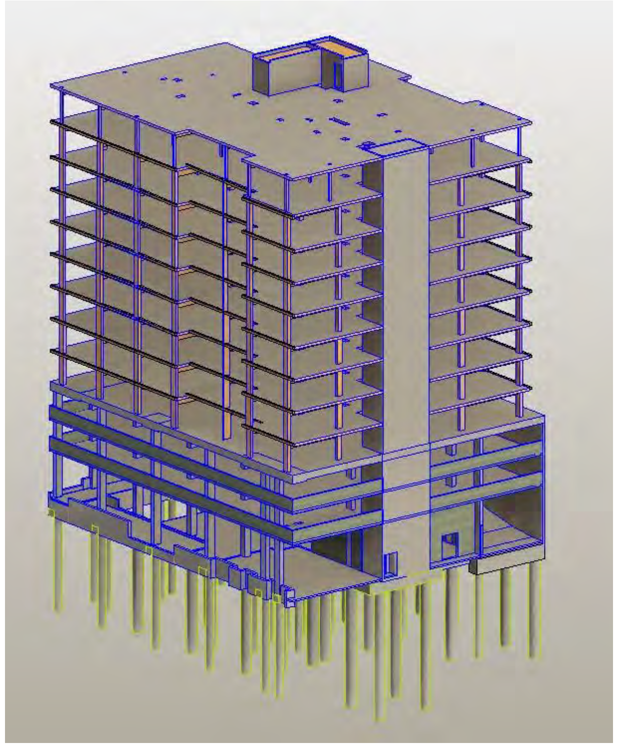
Concrete Cores

20’ x 20’ Grid

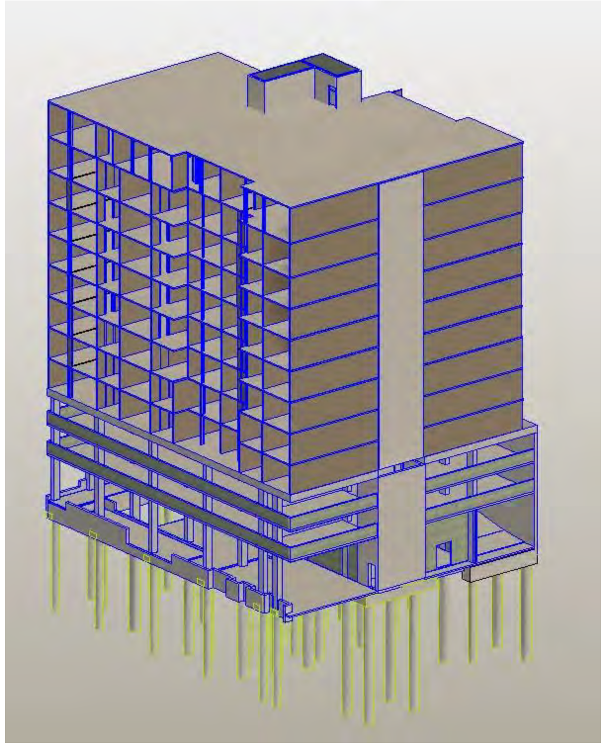


RETURN TO FORM

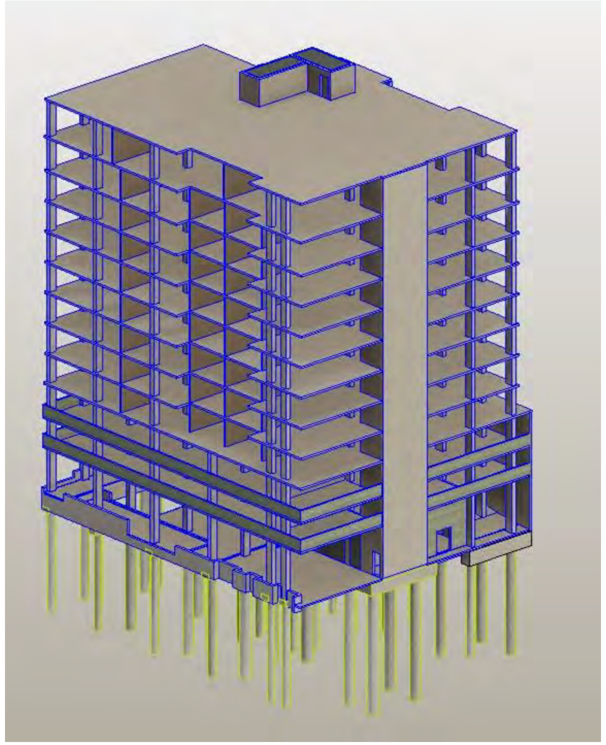
Denver, Colorado



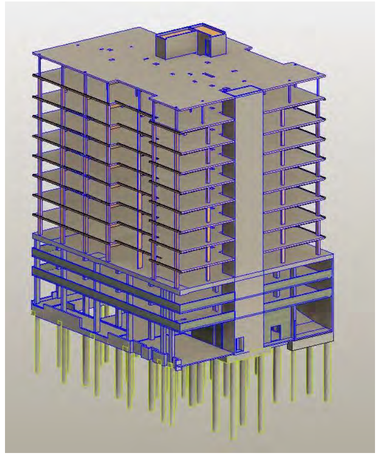
MASS TIMBER
(AS DESIGNED)

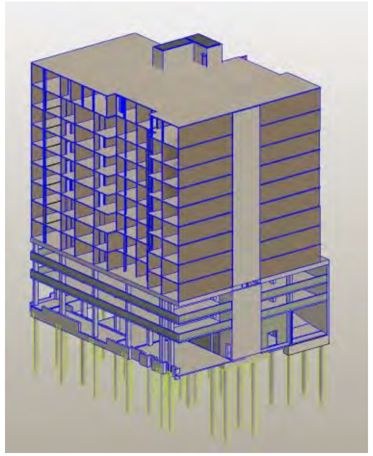


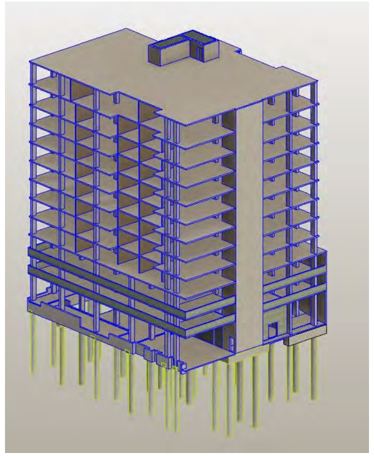
STEEL
(CFS & DECK)

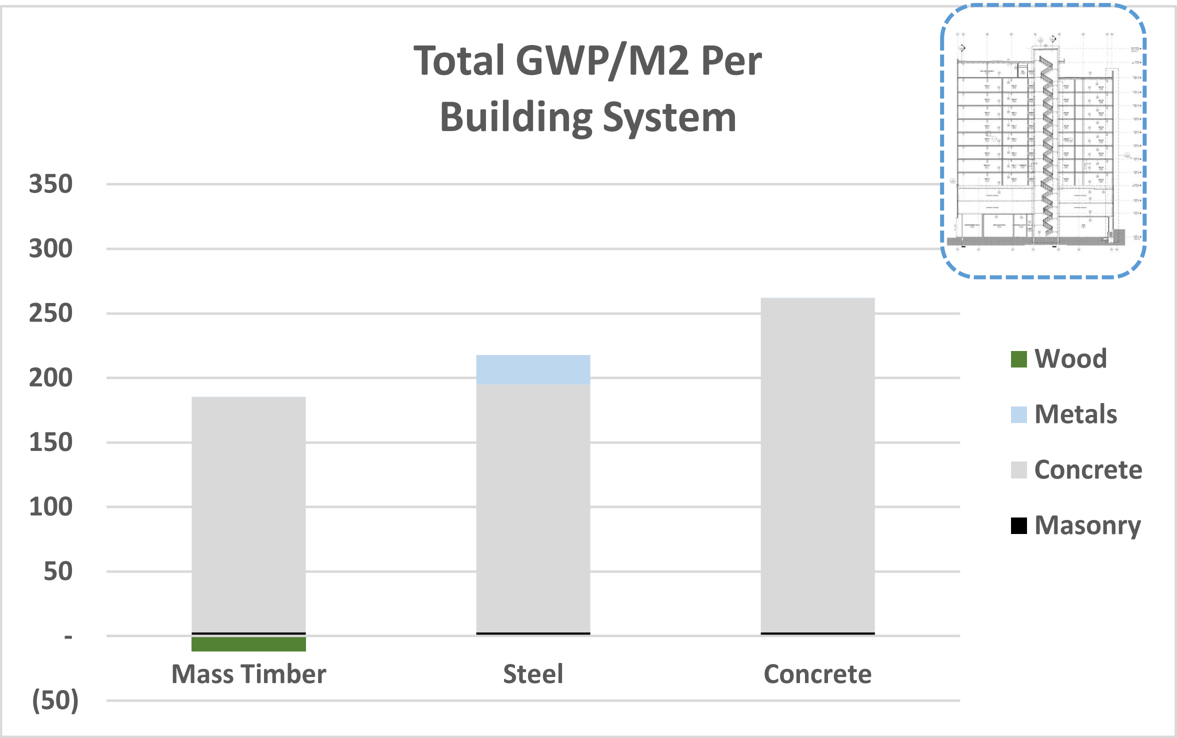


PT CONCRETE

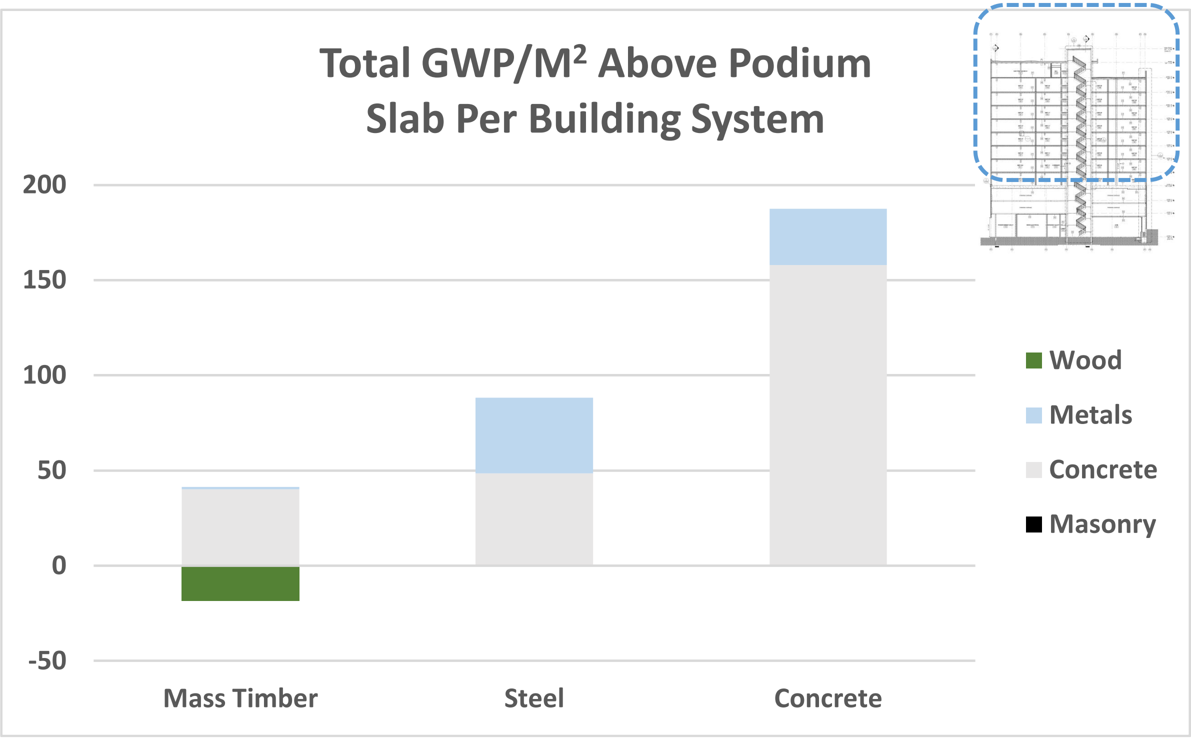




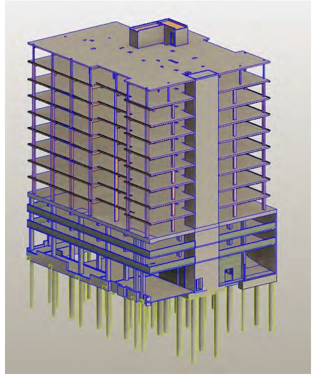
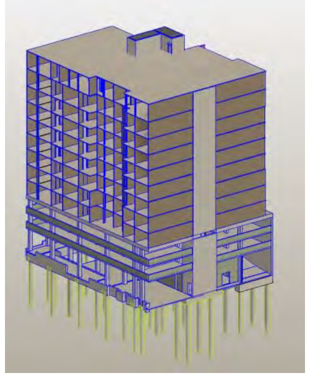
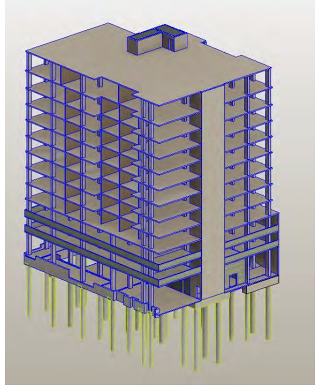
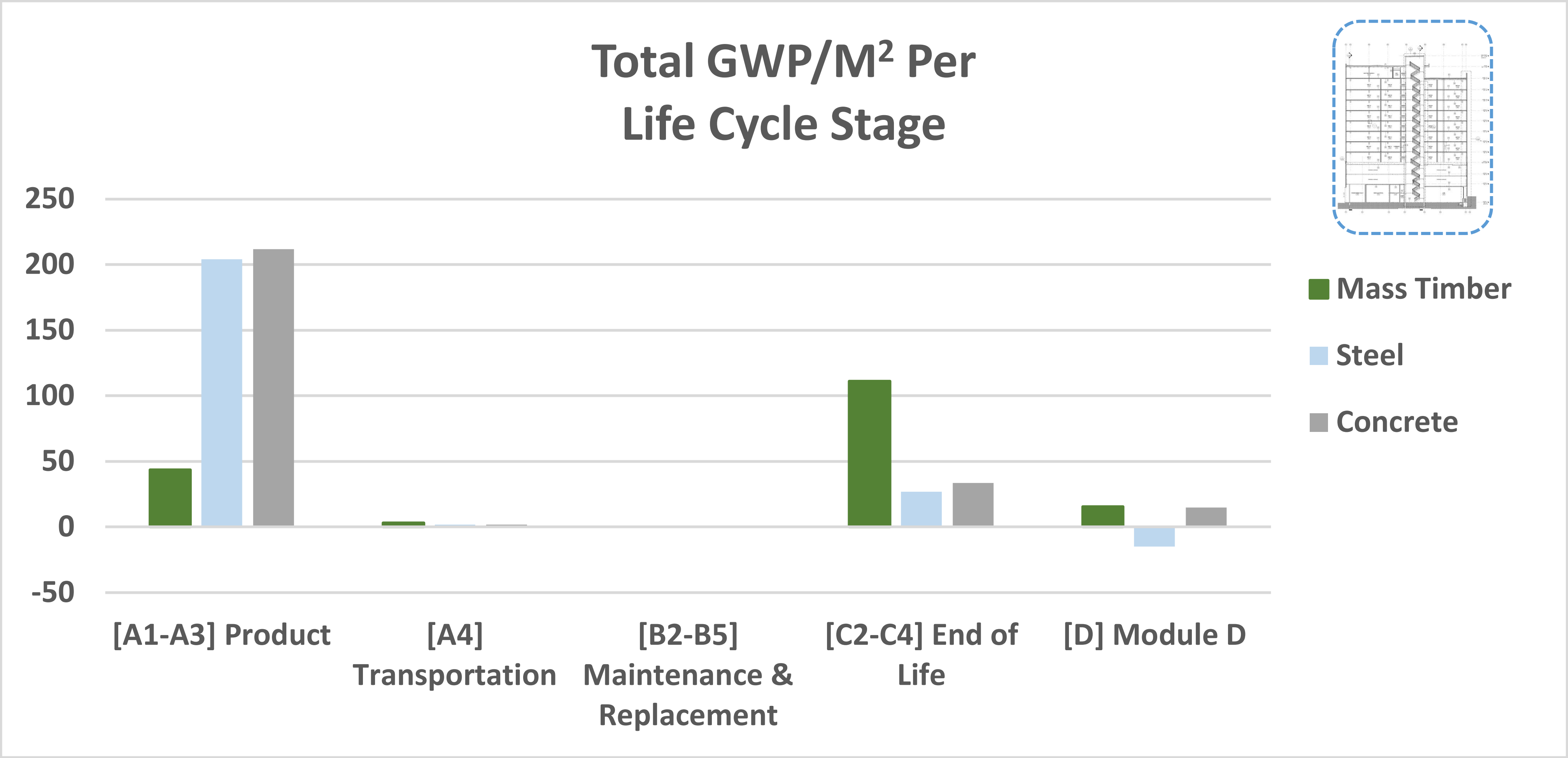




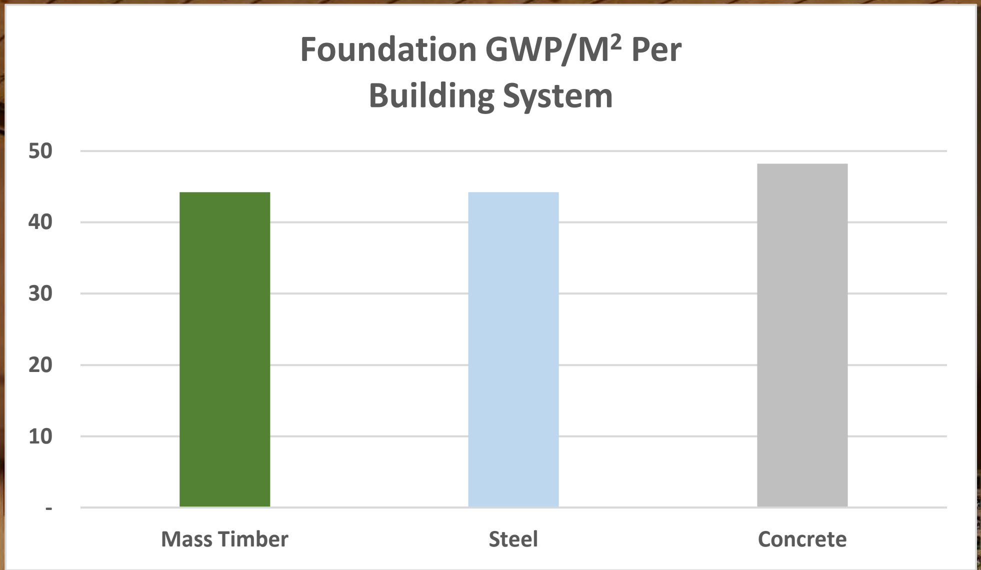
Total GWP/M2 Per
Building System
350
300
250
200
150
100
50
-
(50)
Mass Timber
Steel
Concrete
Wood
Metals
Concrete
Masonry

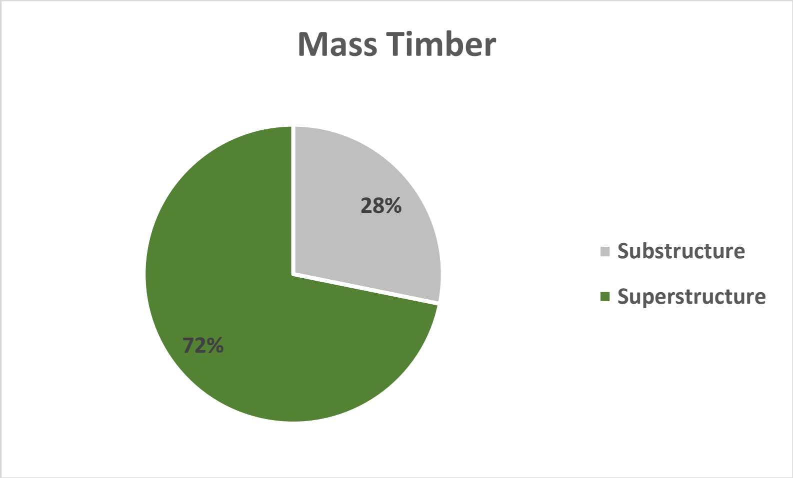


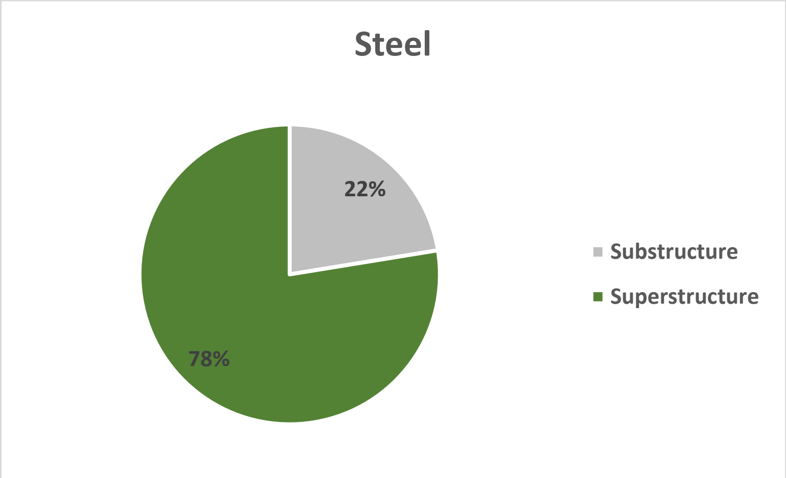
Total GWP/M² Above Podium
Slab Per Building System
200
150
100
50
0
-50
Mass Timber
Steel
Concrete
Wood
Metals
Concrete
Masonry

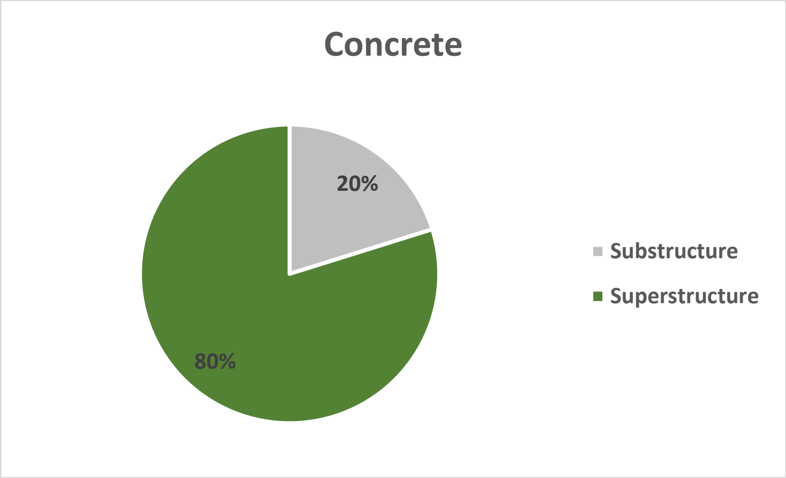





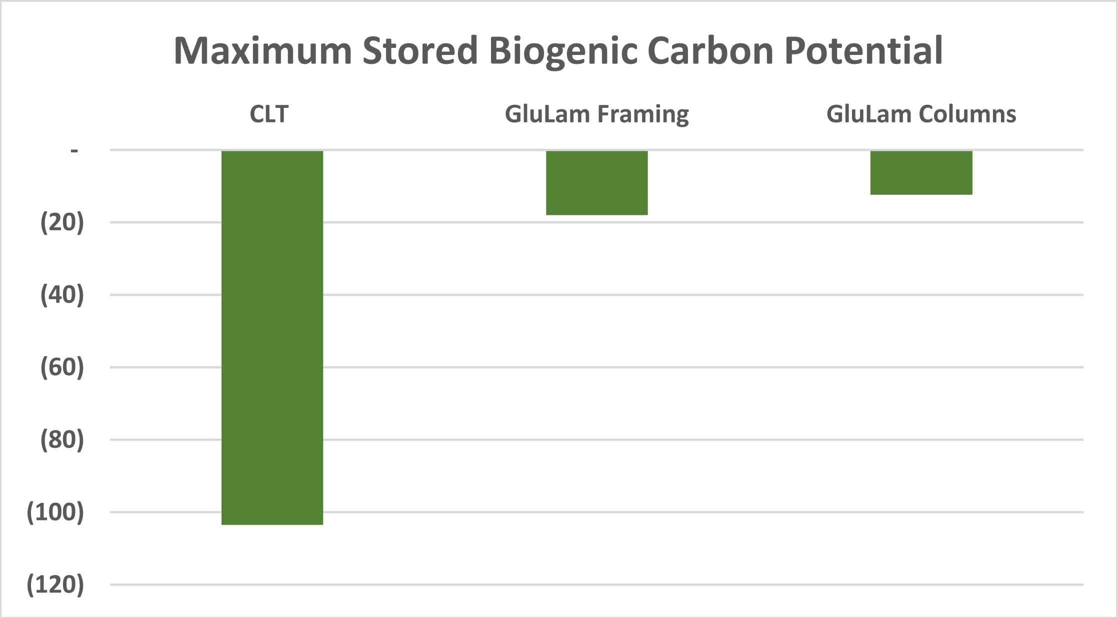
Total GWP/M² Per
Life Cycle Stage
250
200
150
100
50
0
-50
[A1-A3] Product
[A4] Transportation
[B2-B5] Maintenance & Replacement
[C2-C4] End of Life
[D] Module D
Mass Timber
Steel
Concrete


Foundation GWP/M² Per Building System
50
40
30
20
10
-
Mass Timber
Steel
Concrete


Mass Timber
28%
72%
Substructure
Superstructure


Steel
22%
78%
Substructure
Superstructure


Concrete
20%
80%
Substructure
Superstructure



1738 Metric Ton of CO_2eq

= 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

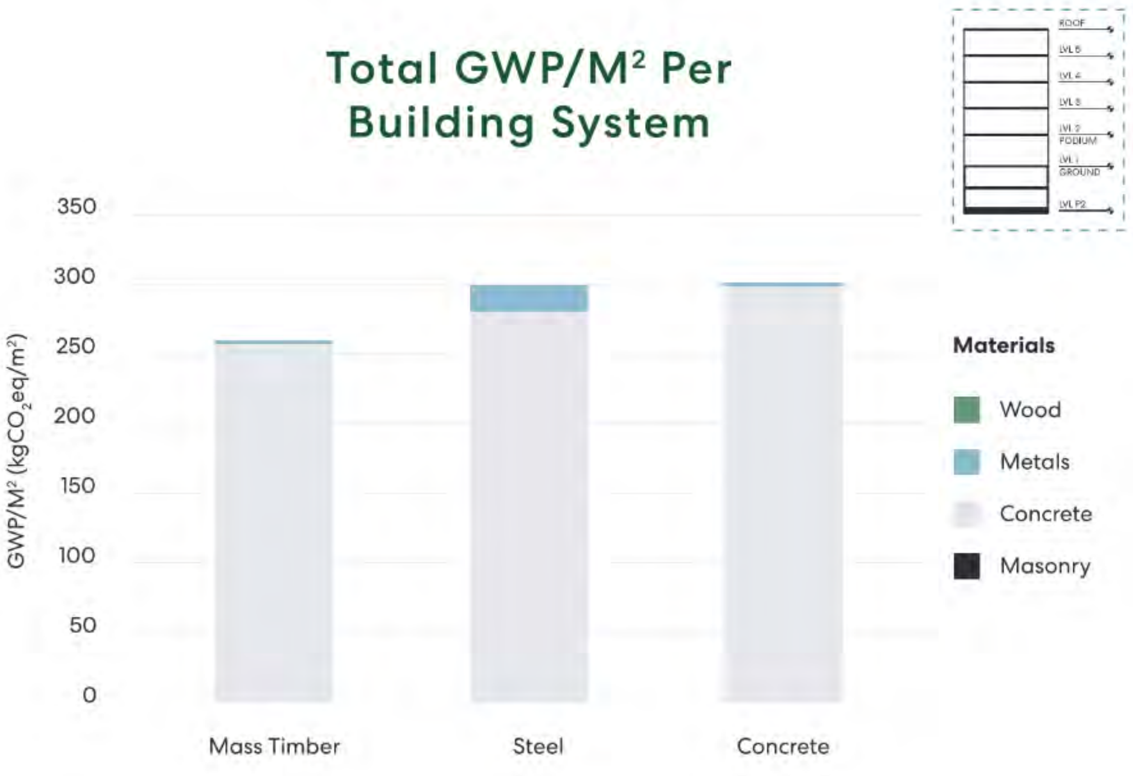
Multifamily / Retail
Type IV-B Construction
12 Story
- No below grade
- L1: Drilled Piers + Concrete Slab on Grade
- L2-L4: Concrete Slabs
- L5 - Roof: Mass Timber

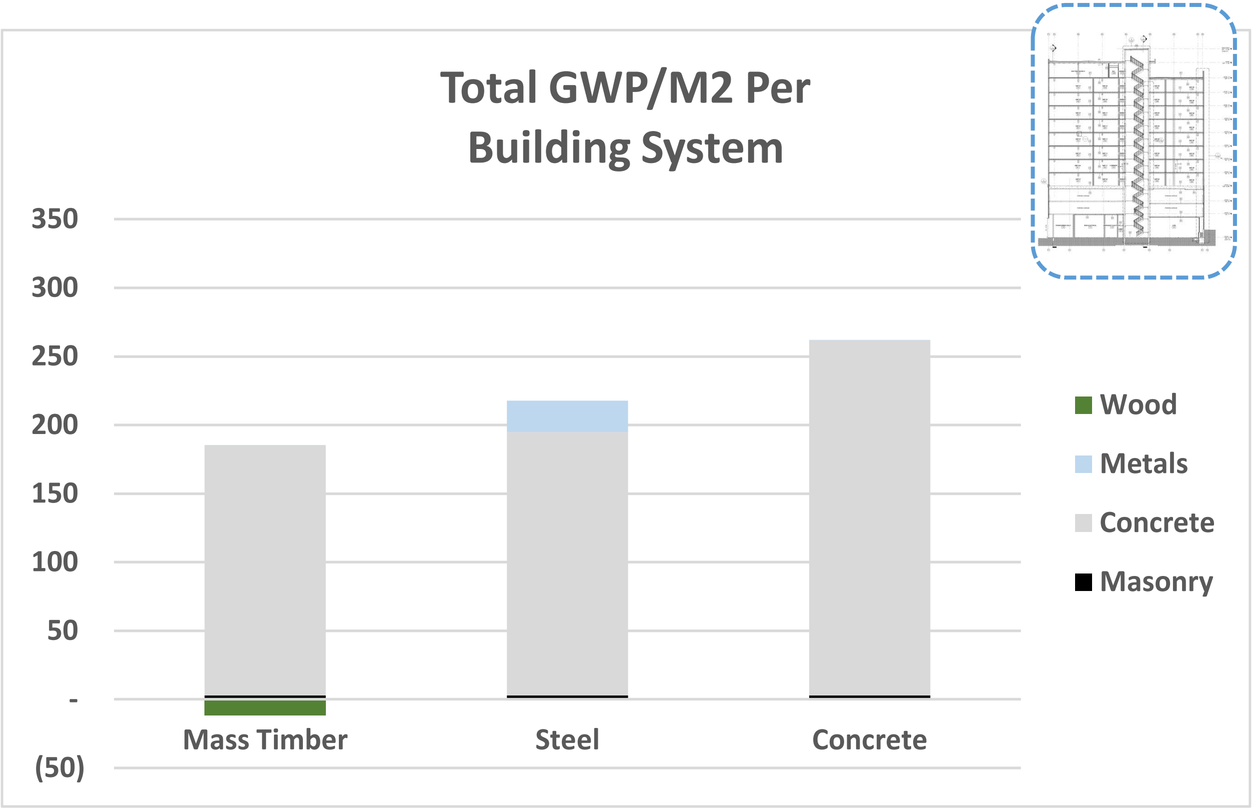
Concrete Cores
20’ x 20’ Grid

PLATTE FIFTEEN
&
RETURN TO FORM

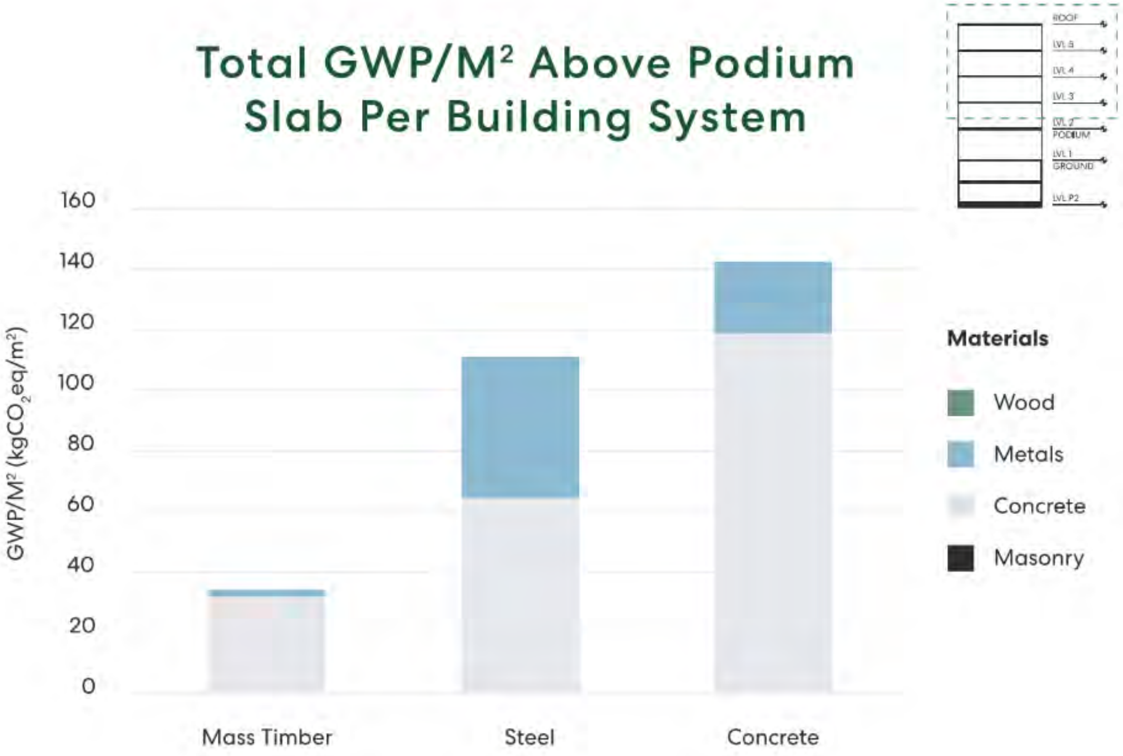
PLATTE FIFTEEN

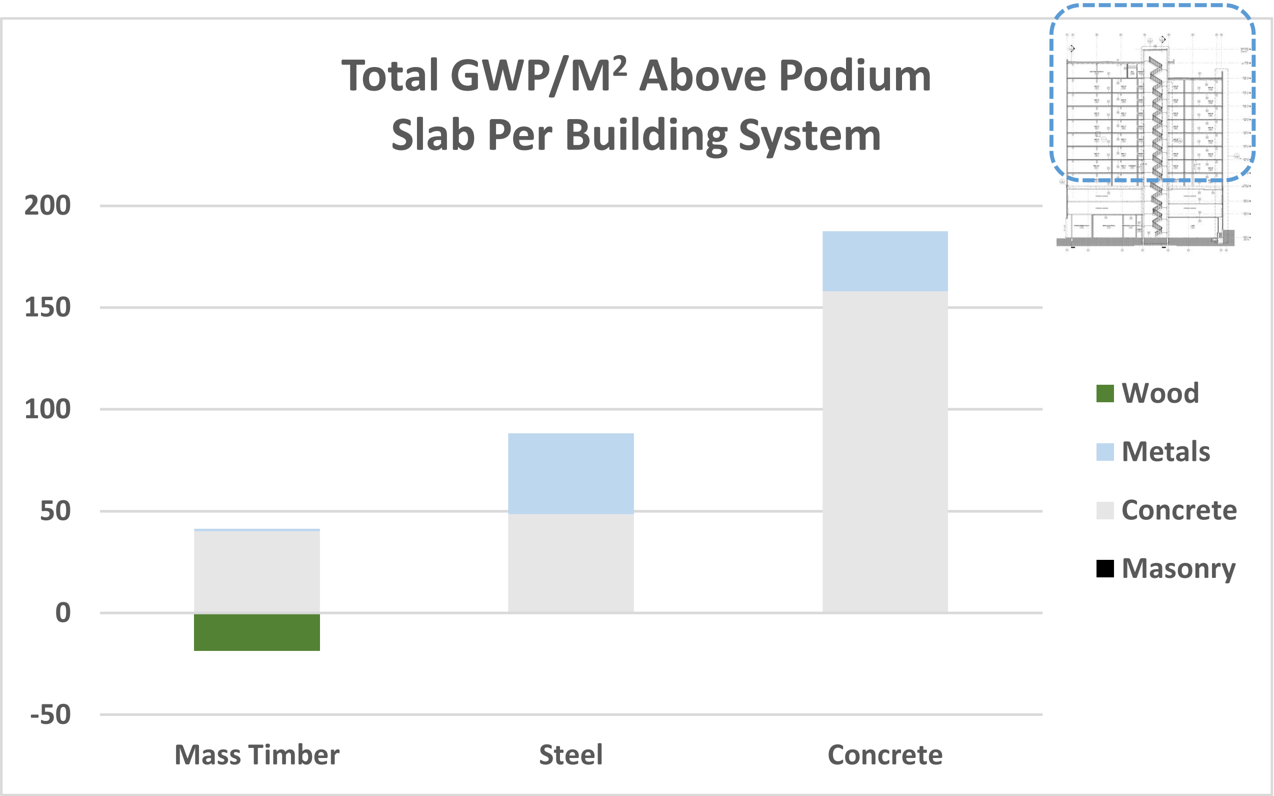
RETURN TO FORM





PLATTE FIFTEEN RETURN TO FORM

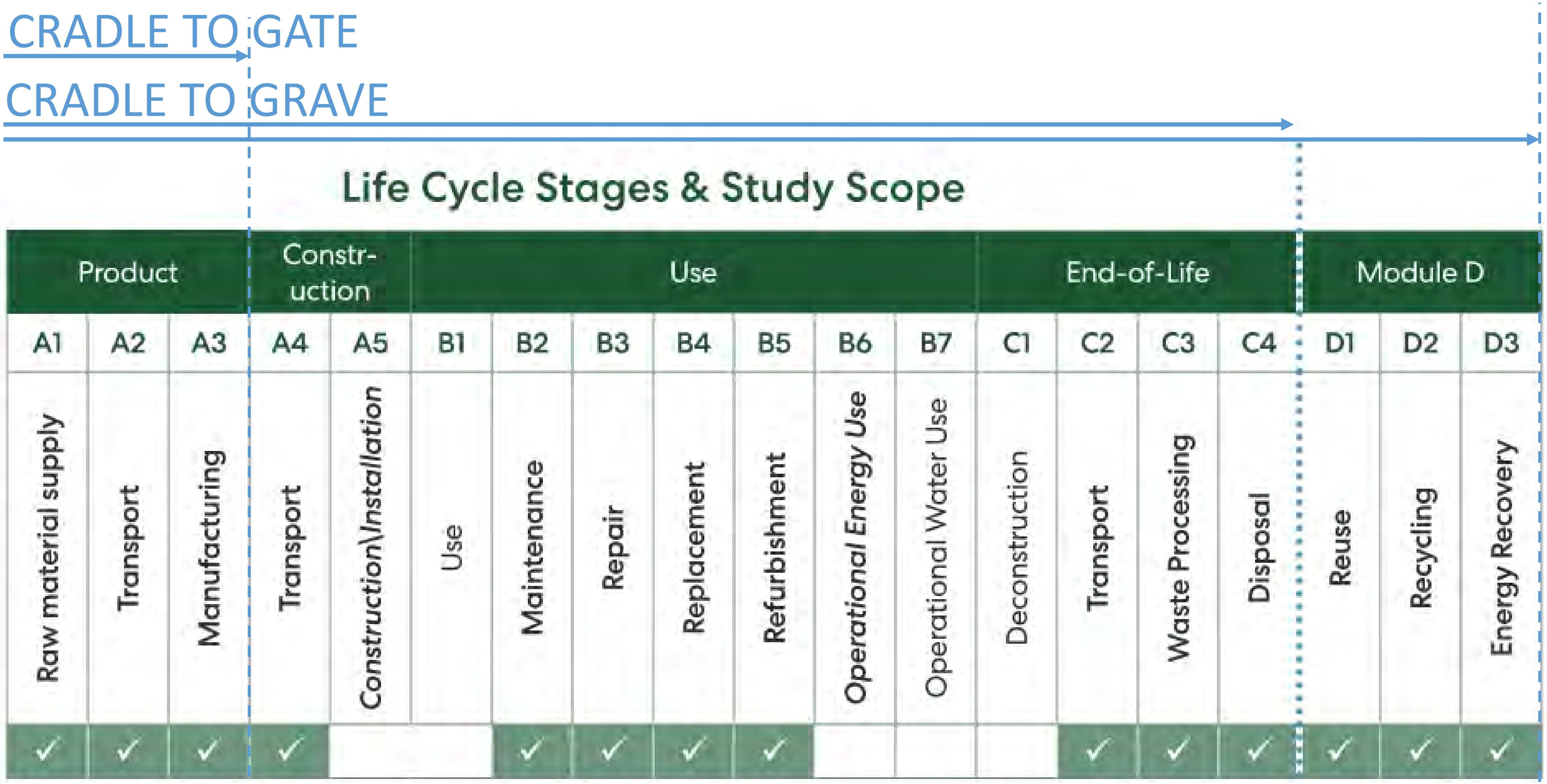




- SYSTEM & MATERIAL COMPARISONS
- BAY LAYOUT COMPARISONS
- DEVELOP BASELINE
- IDENTIFY HOT SPOTS
- DEVELOP REDUCTION STRATEGIES

CONCEPTUAL DESIGN & QUANTIFICATION

Photo by Aleksandar Radovanovic on Unsplash



Life Cycle Stages & Study Scope

Product			Constr-uction		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	**Transport**	**Manufacturing**	**Transport**	***Construction\Installation***	Use	**Maintenance**	**Repair**	**Replacement**	**Refurbishment**	*Operational Energy Use*	Operational Water Use	Deconstruction	**Transport**	**Waste Processing**	**Disposal**	**Reuse**	**Recycling**	**Energy Recovery**
✓	✓	✓	✓			✓	✓	✓	✓				✓	✓	✓	✓	✓	✓

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

[redacted] SYSTEM COMPARISON				
TYPE	**IV-HT**	**IV-HT**	**IV-HT**	**IV-C**
BAY	**20'x32'**	**30'x30'**	**30'x32'**	**20'x32'**
PLINTH MEMBER SIZE				
PLANK	Structurlam V2.1 139V	Structurlam V2.1 139V	Structurlam V2.1 139V	Structurlam V2.1 139V
BEAM	8.75x21	10.75x28.5	12.25x28.5	10.75x21
GIRDER	(2) 10.75x30	(2) 10.75x33	(2) 12.25x33	(2) 10.75x33
COLUMN	14.25x30	14.25x36	14.25x36	14.25x36
CONCRETE	12" CIP SLAB	12" CIP SLAB	12" CIP SLAB	12" CIP SLAB
GYPCRETE TOPPING	-	-	-	-
TYPICAL MEMBER SIZE				
PLANK	Structurlam V2M1.1 105V	Structurlam V2M1.1 105V	Structurlam V2M1.1 105V	Structurlam V2.1 139V
BEAM	8.75x16.5	10.75x28.5	8.75x24	10.75x16.5
GIRDER	(2) 8.75x24	(2) 10.75x33	(2) 8.75x27	(2) 10.75x25.5
COLUMN	14.25x15	14.25x36	14.25x21	14.25x21
CONCRETE	-	-	-	-
GYPCRETE TOPPING	1 1/2" Topping Slab	1 1/2" Topping Slab	1 1/2" Topping Slab	1 1/2" Topping Slab
GREEN ROOF MEMBER SIZE				
PLANK	Structurlam V2.1 139V	Structurlam V2.1 139V	Structurlam V2.1 139V	Structurlam V2.1 139V
BEAM	8.75x21	12.25x27	12.25x27	10.75x21
GIRDER	(2) 8.75x30	(2) 10.75x31.5	(2) 10.75x33	(2) 10.75x31.5
COLUMN	12.25x10.5	12.25x12	12.25x13.5	14.25x15
CONCRETE	-	-	-	-
GYPCRETE TOPPING	-	-	-	-
TOTAL PER SYSTEM				
TYPE	**IV-HT**	**IV-HT**	**IV-HT**	**IV-C**
BAY	**20'x32'**	**30'x30'**	**30'x32'**	**20'x32'**
TIMBER VOLUME (FT^3/FT^2)	0.747	0.782	0.790	0.895
CONC VOLUME (FT^3/FT^2)	0.286	0.286	0.286	0.286
GYPCRETE VOLUME (FT^3/FT^2)	0.071	0.071	0.071	0.071
TIMBER GWP (Crade-to-Gate, $kgCO_2eq/FT^2$)	2.538	2.651	2.677	3.035
CONC GWP (Crade-to-Gate, $kgCO_2eq/FT^2$)	3.611	3.611	3.611	3.611
GYPCRETE GWP (Crade-to-Gate, $kgCO_2eq/FT^2$)	0.559	0.559	0.559	0.559
GWP (Crade-to-Gate, $kgCO_2eq/FT^2$)	6.708	6.820	6.847	7.205
GWP (Crade-to-Gate, $kgCO_2eq/M^2$)	72.175	73.385	73.669	77.523
SEQUESTRATION POTENTIAL ($kgCO_2eq/FT^2$)	-19.698	-20.668	-20.896	-23.638
SEQUESTRATION POTENTIAL ($kgCO_2eq/M^2$)	-211.950	-222.390	-224.836	-254.347
TIMBER VOLUME CHANGE	Basline	4.61%	5.69%	19.74%
GWP CHANGE	Basline	1.68%	2.07%	7.41%
SEQUESTRATION POTENTIAL CHANGE	Basline	4.93%	6.08%	20.00%

NOTES & STATED ASSUMPTIONS

EPDs & LCI data referenced for GWP and Biogenic Carbon Calculations

Structurlam GLULAM, 2020
Structurlam CROSSLAM CLT, 2020
NRMCA National, 5000psi, 20% Fly Ash
NRMCA National, 5000psi, 50% Fly Ash
Self Leveling Underlayment EPD - Gypsum Lime Plaster (Tally)

Total System GWP is reported assuming Concrete with 20% Fly Ash. Total GWP can be reduced by 17-19% if Concrete with 50% Fly Ash is used

Table 1: Structural and Embodied Carbon System Comparison Results

TOTAL PER SYSTEM				
TYPE	**IV-HT**	**IV-HT**	**IV-HT**	**IV-C**
BAY	**20'x32'**	**30'x30'**	**30'x32'**	**20'x32'**
TIMBER VOLUME (FT^3/FT^2)	0.747	0.782	0.790	0.895
CONC VOLUME (FT^3/FT^2)	0.286	0.286	0.286	0.286
GYPCRETE VOLUME (FT^3/FT^2)	0.071	0.071	0.071	0.071
TIMBER GWP (Crade-to-Gate, $kgCO_2eq/FT^2$)	2.538	2.651	2.677	3.035
CONC GWP (Crade-to-Gate, $kgCO_2eq/FT^2$)	3.611	3.611	3.611	3.611
GYPCRETE GWP (Crade-to-Gate, $kgCO_2eq/FT^2$)	0.559	0.559	0.559	0.559
GWP (Crade-to-Gate, $kgCO_2eq/FT^2$)	6.708	6.820	6.847	7.205
GWP (Crade-to-Gate, $kgCO_2eq/M^2$)	72.175	73.385	73.669	77.523
SEQUESTRATION POTENTIAL ($kgCO_2eq/FT^2$)	-19.698	-20.668	-20.896	-23.638
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TIMBER VOLUME CHANGE	Basline	4.61%	5.69%	19.74%
GWP CHANGE	Basline	1.68%	2.07%	7.41%
SEQUESTRATION POTENTIAL CHANGE	Basline	4.93%	6.08%	20.00%

CONCEPTUAL DESIGN

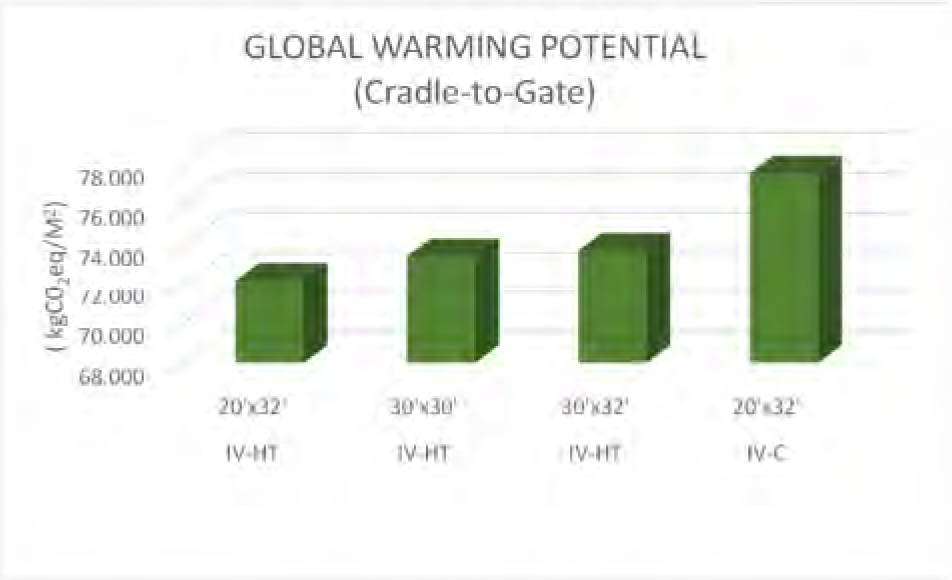


Figure 2: Total GWP System Comparison

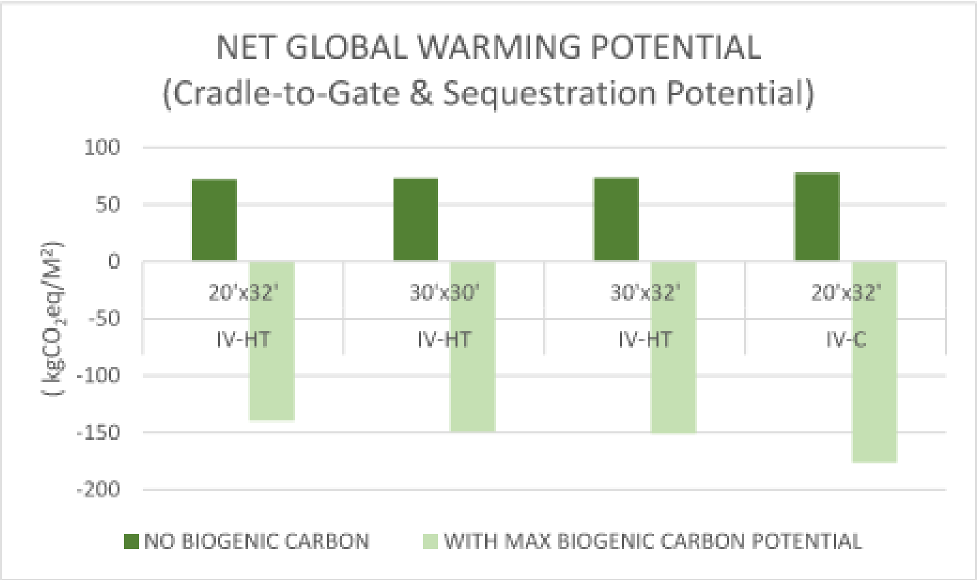
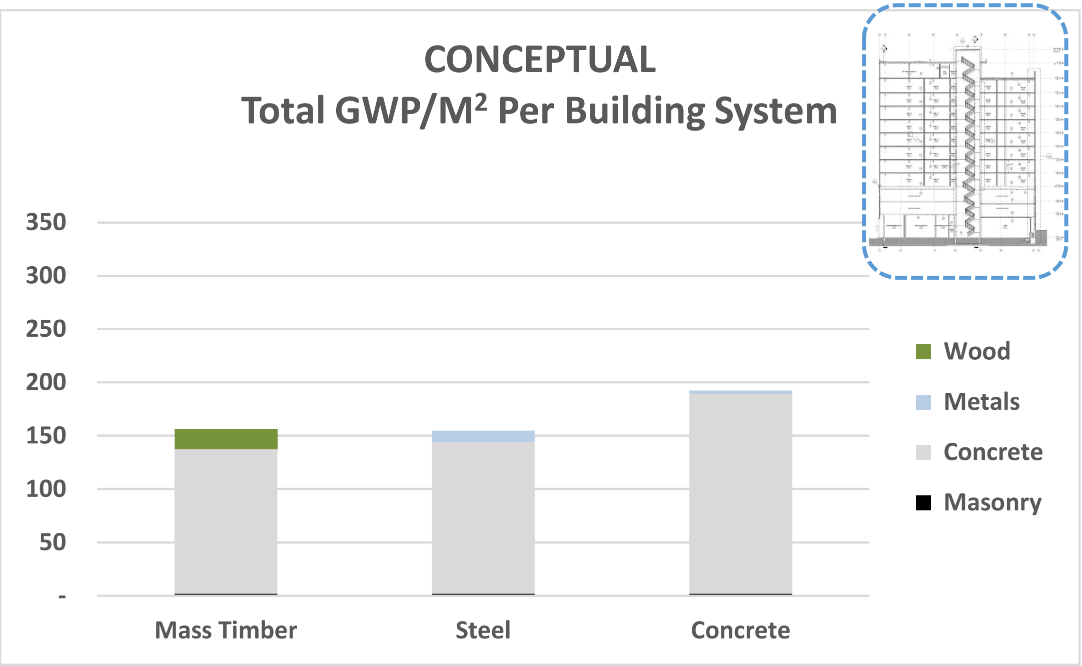
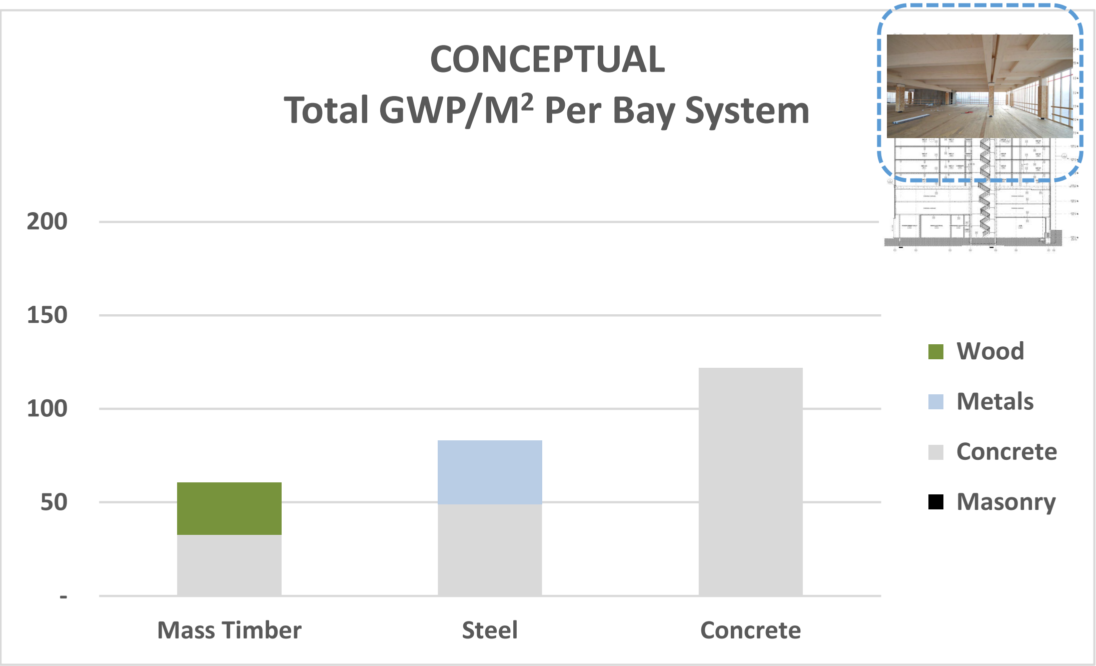


Figure 5: Net GWP with and without the potential offsets of Biogenic Carbon

CONCEPTUAL DESIGN

RETURN TO FORM





CONCEPTUAL DESIGN

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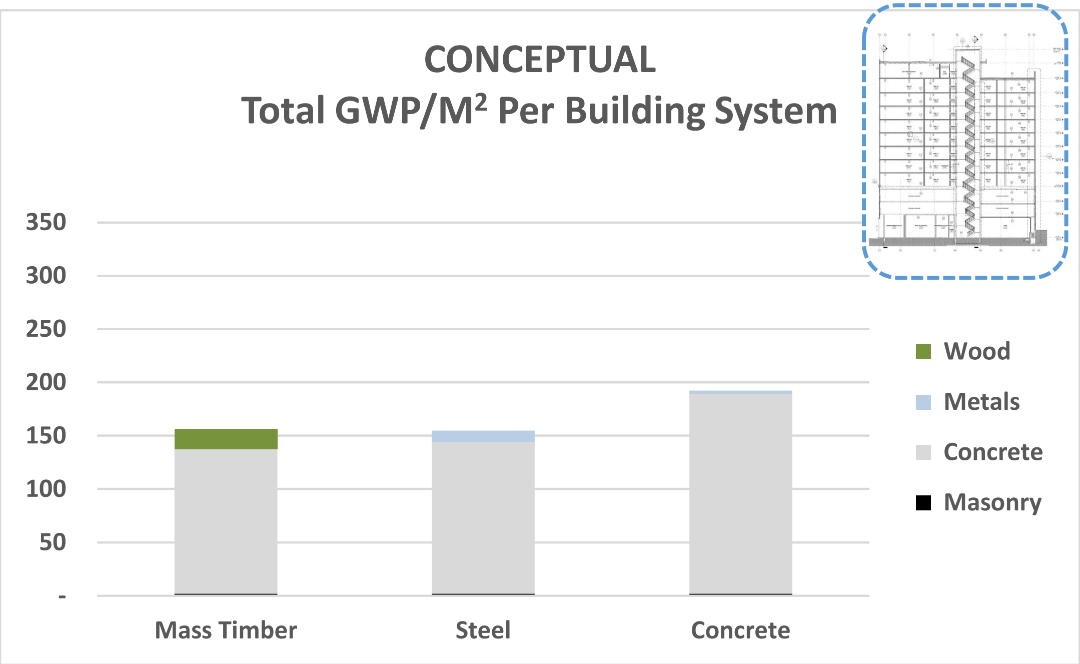

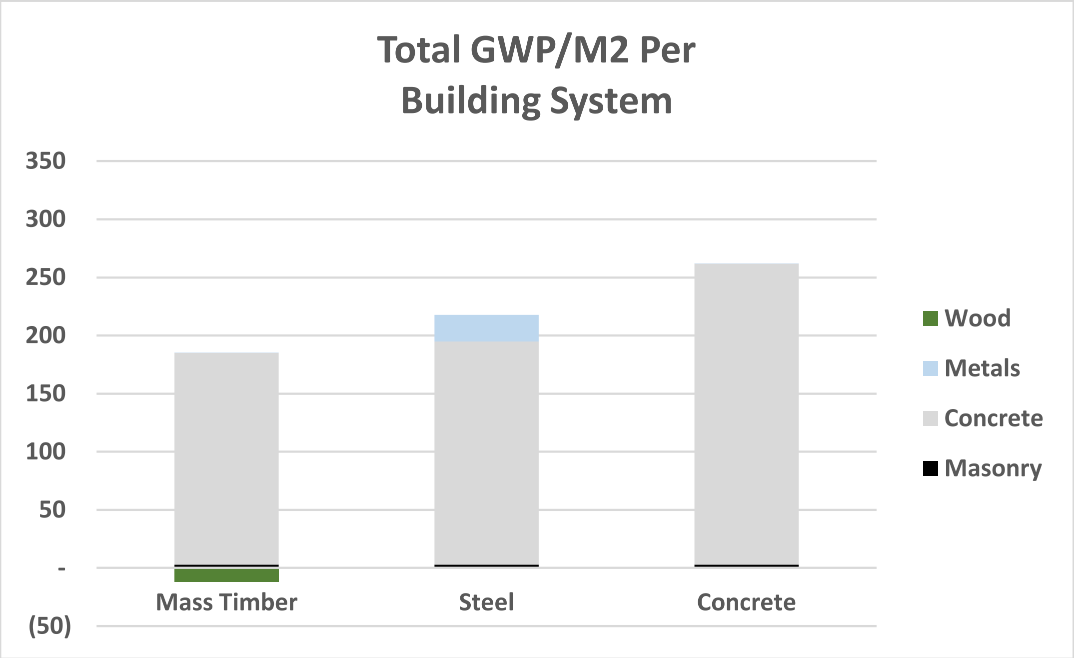

CONCEPTUAL DESIGN

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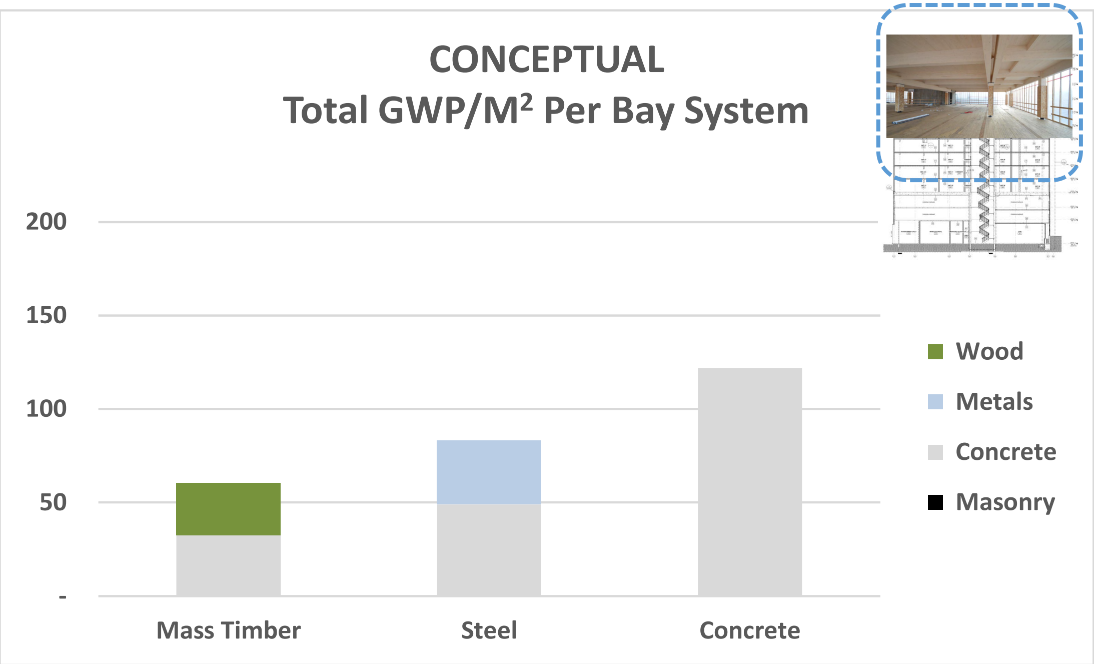
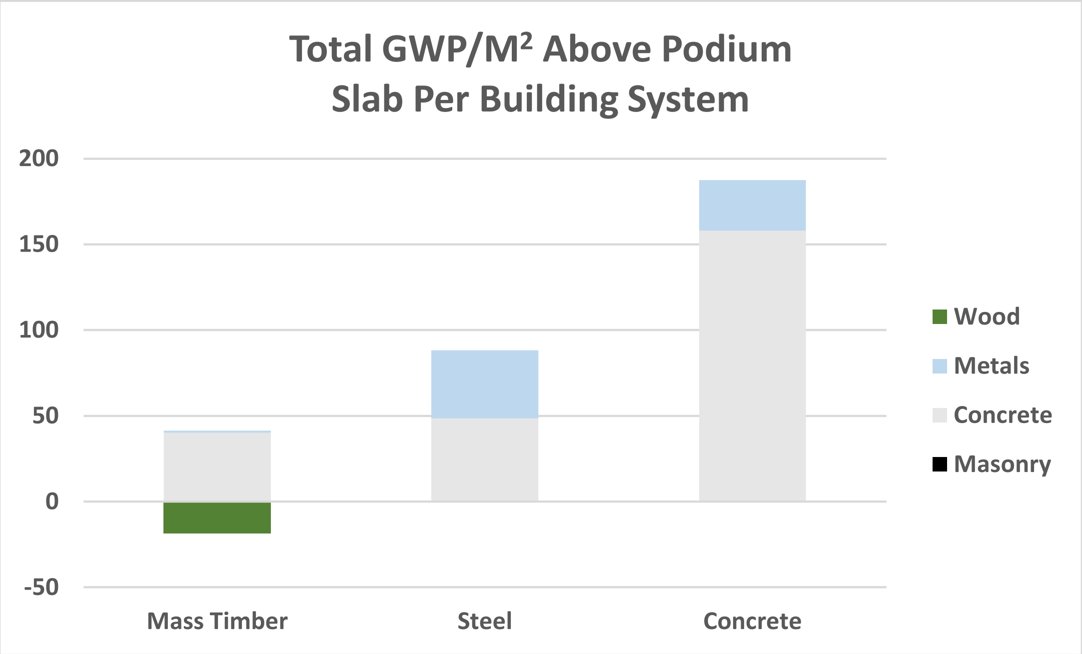




CONCEPTUAL DESIGN

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**

Photo Credit: JC Buck

MASS TIMBER IS SUSTAINABLE…

- LOW EMBODIED CARBON
- STORES CARBON
- RENEWABLE
- REUSABLE
  EASE OF DECONSTRUCTION & RECOVERY

Photo by Aleksandar Radovanovic on Unsplash

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
- EARNS CARBON CREDITS, GREEN FINANCING

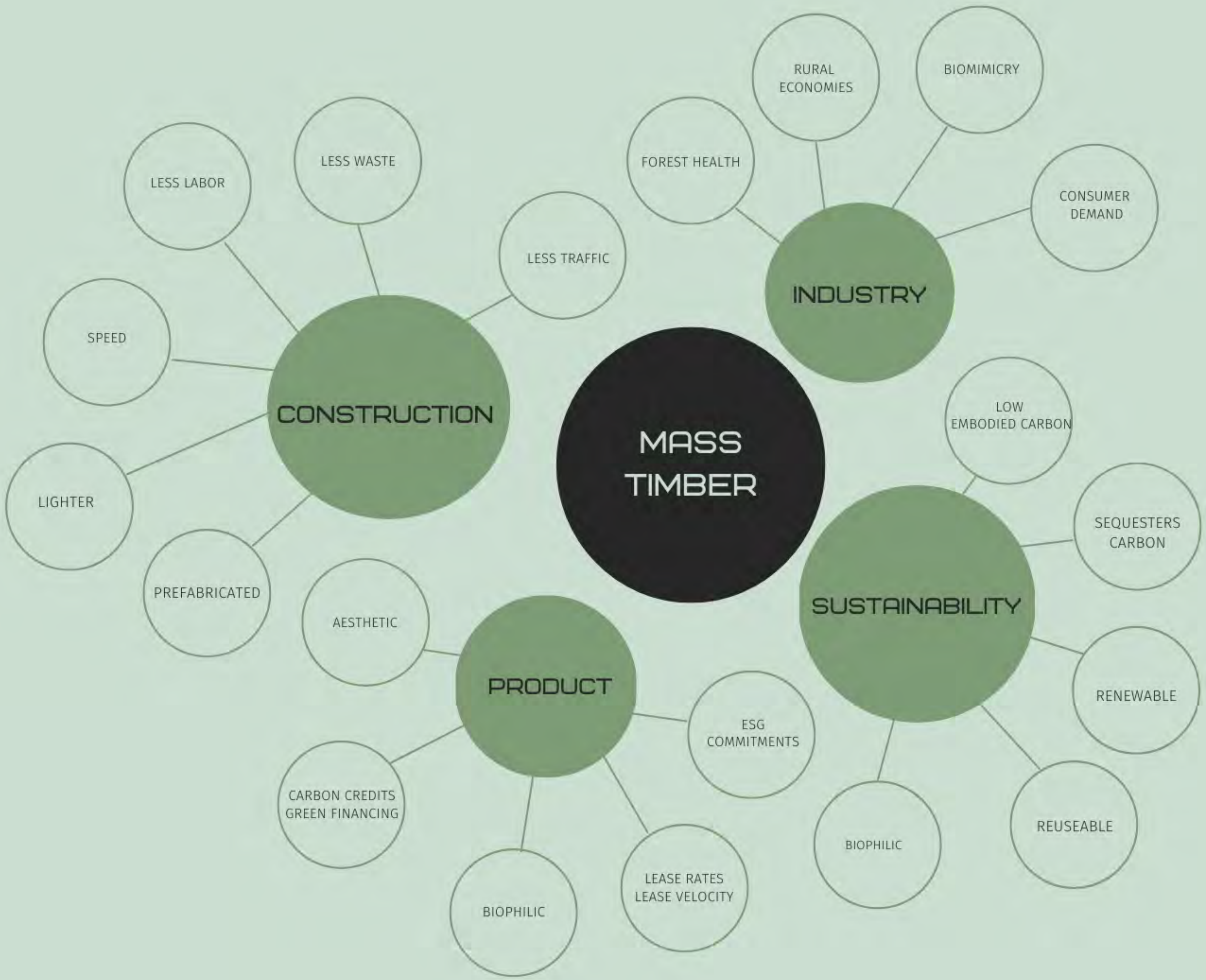
Photo Credit: KL&A

MASS TIMBER INDUSTRY…

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

Photo by Joel Vodell on Unsplash


Photo Credit: JC Buck



KL&A Engineers & Builders

THANK YOU

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

Photo Credit: JC Buck