CLT Passive House Confidential: The Financial and Logistical Synergy of PH and Mass Timber

Christina Aßmann and Michael Hindle, Passive to Positive
Alex Yoon, Monte French Design Studio
Matthew Richardson, BKS

Curated by Sara Bayer (MAP) and Aidan Mayer (Northeastern University)

Northeast Sustainable Energy Association (NESEA)
September 15, 2022
MASS TIMBER - PASSIVE HOUSE CONFIDENTIAL-
How PH + mass timber synergies yield financial + logistical viability
OUR CLIMATE IS CHANGING FASTER THAN ANTICIPATED

1 DEGREE TEMPERATURE RISE RESULTS IN 10% LOWER AGRICULTURAL YIELDS

Temperature map images: U.S. Global Change Research Program

Image credit: Oregon Public Broadcasting
WE NEED MORE COURAGE!

INCREMENTALISM = INEVITABLY
MASS TIMBER AND PASSIVE HOUSE

BENEFITS

AESTHETICS AND BIOPHILIA

It just looks better.
MASS TIMBER AND PASSIVE HOUSE

BENEFITS

THERMAL BRIDGES COMPARISON:

CONCRETE DECK FLOOR SLAB EDGE WITH STEEL STUD AND 2" CI + BRICK ANGLE

VS.

CLT FLOOR PLATE AND FRT FRAME WALLS WITH 2"CI + BRICK ANGLE

IMPACTS:

HEAT LOSS IS REDUCED BY 87%

INTERIOR SURFACE TEMPERATURES INCREASE BY 9º F

CORRESPONDINGLY REDUCES RISK OF MOLD GROWTH
MASS TIMBER AND PASSIVE HOUSE

BENEFITS

ENERGY AND THERMAL BRIDGES
MASS TIMBER AND PASSIVE HOUSE

BENEFITS

IAQ AND CONDENSATION RISK
MASS TIMBER AND PASSIVE HOUSE

BENEFITS

REDUCED USE OF FINISHES

BUILDING AS USUAL WOULD CONSUME:

- 189,000 lbs of gypsum wall board
- 3,000 lbs of paint for finish ceilings.

An additional 212,500 lbs of gypsum wall board (3,035 sheets) and 3,200 lbs of paint for the finish face of the exterior walls.

79 KING STREET AIMS TO REDUCE:

- 50% of ceiling materials and nearly 100% of finishes at exterior walls
- fireproofing is integral to timber elements
- additional fireproofing and sound insulation required
MATERIAL SELECTION FOR REGENERATIVE IMPACT
THE NEW CARBON ARCHITECTURE
CAPTURE AND STORE CARBON

LOWER EMBODIED CARBON
THE NEW CARBON ARCHITECTURE
CAPTURE AND STORE CARBON

SHORTER CONSTRUCTION DURATION
11 EAST LENOX ST.  
ROXBURY, MA

DEVELOPER: BOSTON REAL ESTATE COLLABORATIVE
ARCHITECT: MONTE FRENCH DESIGN STUDIO A+P
GC: HAYCON
CLT: NORDIC STRUCTURES

7 STORIES – 37 APARTMENTS
CLT PODIUM AND SUPER STRUCTURE
LOW CARBON ENVELOPE
PASSIVE HOUSE
PV ARRAY
GROUNDWATER RECHARGE
79 KING STREET, NORTHAMPTON, MA

DEVELOPER: SPIRITOS PROPERTIES
ARCHITECT: BKSK
STRUCTURAL: HOLMES STRUCTURES
MEP: BLW ENGINEERS
GC: WESTERN BUILDERS

66 UNIT MULTI-FAMILY
MASS TIMBER STRUCTURE, CLT SHELL + CORE
LOW CARBON ENVELOPE
LOW-REFRIGERANT MEP
PASSIVE HOUSE
ROOF PV ARRAY
11 E Lenox
Boston’s First Ground-up Mass Timber Building
Project Summary

• Market-rate multifamily
  • 34 units, standard size units
  • 8 parking spaces
• 43,500gsf
• 7 stories, 70ft
• PHIUS+ 2018 PreCertified
• Type IV construction
  • 2015 IBC code variance project
• Under construction, Q4 2022 completion
Energy Summary:

- PHIUS+ 2018 PreCertified
- 12.8 pEUI
- 81% reduction over 2030 Challenge baseline
- 45 kW PV system

PHIUS+ 2018 Metrics

- Heating demand: 1.64 vs. 3.8
- Cooling demand: 4.67 vs. 5.9
- Heating load: 2.83 vs. 3.9
- Cooling load: 2.53 vs. 3.1
- Source energy: 3,605 vs. 3,840
- Site energy: 12.8
Building Systems Summary

- Mass timber structure with modular prefab composite cores
- Shallow foundations with no basement
- Non-load bearing wood stud rainscreen exterior wall
- Per unit ERV fresh air, centralized heat pump heating/cooling, semi-decentralized heat pump hot water
Building Systems: Structure

- Mass timber structure (by Nordic)
  - Glulam mass timber posts and beams
  - Cross laminated timber slabs
- Prefabricated modular steel vertical cores with CIP
- 7 steel transfer members at grade
- Shallow foundation system with rammed aggregate piers
Building Systems: MEP

• Fresh air: Per unit decentralized Panasonic ERVs

• Heating / Cooling: Centralized Daikin VRF system with wall mount ductless and ceiling mount ducted units

• Hot water: SANCO2 heat pump

• PV generation: 40,000 kWh/yr
Building Systems: Envelope & Assemblies

- **Subgrade**
  - 2ft min. glass aggregate gravel (R-40 min) insulated backfill
  - Recycled XPS frost wall insulation

- **Exterior Wall**
  - Terracotta & fiber cement rainscreen cladding system
  - 2-3/4” Armorwall VP structural insulating panel, integrated vapor permeable air and water barrier, R-15 continuous
  - 2x6 FRT wood stud with R-21 fiberglass batt cavity insulation
Building Systems: Envelope

- Roof
  - TPO roof membrane
  - Protection board
  - Min. 2" tapered XPS insulation board (R-9)
  - 9" recycled polyiso board insulation (R-42)
  - Vapor barrier
  - 7" CLT slab
79 King Street
Downsizing with Massive Timber
NATURALLY OCCURRING RETIREMENT COMMUNITY (NORC)

DYNAMIC COLLEGE COMMUNITY
eclectic restaurants, lively arts and music scene known as “Cambridge West”

FIVE COLLEGE LEARNING IN RETIREMENT (based at Smith College) offers lifelong learning, lectures, and special interest programs

BORDERING BIKE TRAIL
active lifestyles, scenic beauty
walk score = 96, bike score = 97

SHORTAGE OF ACTIVE ADULT 55+ HOUSING
Northampton and surrounding communities have not yet delivered 55+ market multifamily opportunities

EASILY ACCESSIBLE
1.5 miles to I-91 | 50 mins to Hartford, CT & Bradley Int’l Airport | Amtrak station in walking distance

79 King Street
Project Summary

79 King Street
79 King Street
79 King Street
EXPECTED MEMBER SIZES AND VOLUMES

1. COLUMNS AND BEAMS
   GLULAM COLUMNS GL 8 3/4 x 13 1/2
   GLULAM BEAMS 6 3/4 x 13 1/2

2. FLOOR AND ROOF SLABS
   6 7/8" E-RATED CLT FLOOR PANEL WITH 1-5/8" FIRE-RESISTANCE RATING

3. EXTERIOR WALLS (60% solid)
   3-PLY V-RATED CLT WITH 1-5/8" FIRE-RESISTANCE RATING

4. STAIR, ELEVATOR CORES AND SHAFTS
   6 7/8" V-RATED CLT SHAFT WALL WITH 2-5/8" FIRE-RESISTANCE RATING

FIBER VOLUME

<table>
<thead>
<tr>
<th></th>
<th>FIBER VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3,287 ft³</td>
</tr>
<tr>
<td></td>
<td>4,410 ft³</td>
</tr>
<tr>
<td></td>
<td>62,352 ft³</td>
</tr>
<tr>
<td></td>
<td>7,040 ft³</td>
</tr>
<tr>
<td></td>
<td>5,602 ft³</td>
</tr>
<tr>
<td>---</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td>82,892 ft³</td>
</tr>
</tbody>
</table>

79 King Street
79 King Street
CARBON
WE NEED THREE PLANETS
CARBON LIFE-CYCLE STAGES

SOURCE: ARCHDAILY
REDUCING OPERATIONAL ENERGY DEMAND IS NOT ENOUGH

THE TIME VALUE OF CARBON
PUTTING EMISSIONS IN PERSPECTIVE: UPFRONT CARBON + HIGH PERFORMANCE BUILDING DESIGN

As building systems become more efficient, the short term impact of materials rise to the surface.

COMMON EMISSIONS IMPACT MEDIUM SCALE RESIDENTIAL

Source: LETI Embodied Carbon Primer

60 year lifespan code building
60 year lifespan high performance building
10 year lifespan high performance building

Source: adapted from K. Simonen, Life Cycle Assessment, 2014
CARBON ARCHITECTURE
CAPTURE AND STORE CARBON
At the Ellen MacArthur Foundation we have tried to capture the essence of the circular economy in the diagram above, which is somewhat understandably nicknamed the ‘butterfly diagram’.

The diagram tries to capture the flow of materials, nutrients, components, and products, whilst adding an element of financial value. It builds on several schools of thought, but is perhaps most recognisably influenced by Cradle to Cradle’s two material cycles.
WE NEED THREE PLANETS

RETROFIT WITH POLYISO vs. BIOGENIC INSULATION

NEGLEY RETROFIT WALL COMPARISON

Negley Retrofit Wall Type 2

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Base wall materials</td>
<td>Polyiso</td>
<td>Sheathing</td>
<td>wood fiber - int.</td>
<td>wood fiber - ext.</td>
<td>total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>reclaimed polyiso-all</td>
<td>wood fiber - int.</td>
<td></td>
<td>BoD</td>
<td>reclaimed polyiso-all</td>
<td>wood fiber - ext.</td>
<td>total</td>
<td>BoD</td>
</tr>
<tr>
<td>All Bio-Gen</td>
<td>reclaimed polyiso-all</td>
<td></td>
<td>BoD</td>
<td>wood fiber - ext.</td>
<td>wood fiber - ext.</td>
<td>total</td>
<td>BoD</td>
</tr>
<tr>
<td>wood fiber - int.</td>
<td></td>
<td></td>
<td>BoD</td>
<td>reclaimed polyiso-all</td>
<td>wood fiber - ext.</td>
<td>total</td>
<td>BoD</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td></td>
<td>BoD</td>
<td>reclaimed polyiso-all</td>
<td>wood fiber - ext.</td>
<td>total</td>
<td>BoD</td>
</tr>
</tbody>
</table>
PANEL DISCUSSION
BOSTON AND NYC POLICY

CARBON FREE BOSTON
City of Boston

BERDO 2.0
City of Boston

MASS TIMBER ACCELERATOR
City of Boston

MASS SAVE REBATES
Massachusetts State Utilities Collaborative & MA DOER

Local Laws 31 and 32 (2016)
NYC Public Buildings

CLIMATE MOBILIZATION ACT (2019)
New York City

Low-Embodied-Carbon Concrete Leadership Act
New York State
INCREASING HOUSING DEMAND
LEADING TO DENSITY
HOUSING BOOM, LAND SCARCITY, INCREASING LAND COSTS

TRIPLE DECKERS > PODIUM > MIDRISE/HIGHRISE

WOOD FRIENDLY MARKET
VAST MAJORITY OF NON-HIGH-RISE CONSTRUCTION IS WOOD
(Type III & V)

PANEL DISCUSSION
MARKET CONDITIONS
PANEL DISCUSSION
MASS TIMBER & PASSIVE HOUSE SYNERGIES

GRAPHICS COURTESY OF RICHARD PEDRANTI ARCHITECTS
11 E Lenox – DENSITY FEASIBILITY WITH SYSTEMS EFFICIENCY

PANEL DISCUSSION
MASS TIMBER & PASSIVE HOUSE SYNERGIES

- Space is a bigger cost premium than MEP systems
- Minimal right size system
- Minimal plenums and chases
- Minimized structural penetrations

7-Story Podium vs Mass Timber

- Mass Timber:
  1. Faster construction
  2. Less sub
  3. Conflict/Coordinating
  4. Condensed floor-floor
  5. Reduced foundation loads

- Podium:
  1. Slower construction
  2. Extra trades
  3. Higher floor-floor

Building would be classified as a high-rise in Massachusetts but not by IBC.
MINIMAL PLENUMS

- 11 E LENOX < 70FT TALL
- 9’-8” FLOOR-TO-FLOOR
- MASS TIMBER STRUCTURALLY ALLOWS FOR 7 UNDER 70
- PHIUS DESIGN MINIMIZED PLENUM DEPTHS TO 10” - 11” CLEAR
MINIMIZED STRUCTURAL PENETRATIONS

- BEAM PENETRATIONS REQUIRED
- LARGEST PENETRATION $H = 5\ 3/8''$
- LARGEST DUCT $\Ø = 4''$
BUILDING WEIGHT & GROUND IMPROVEMENT REDUCTIONS

- LIGHTWEIGHT MASS TIMBER STRUCTURE & FOAM GLASS AGGREGATE BACKFILL ALLOWED FOR SHALLOW FOUNDATION SYSTEM

- ALTERNATE WAS MORE COSTLY SOIL REPLACEMENT OR HELICAL PILES
VERTICAL CORES – COMPOSITE PREFAB MODULES AND CLT CORES

11 E LENOX

79 KING STREET
EXTERIOR WALLS – LIGHT WEIGHT TIMBER FRAMING AND CLT WALLS

11 E LENOX

79 KING STREET
EXTERIOR WALLS – INTERIOR FINISHES

11 E LENOX

79 KING STREET