Three London Projects: Reducing Carbon Footprint via Smaller, Lighter Structural Grids

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Reducing Carbon Footprint via Smaller & Lighter Structural Grids

Presentation to CTBUH Steel-Timber Hybrid Buildings Conference, Chicago
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Introductions

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Agenda

01  Why should we design using mass timber?

02  How we are proposing its usage

03  Retrofit Case Study

04  Riverside New Build Case Study

05  Major Project Case Study

06  The next steps
01 Why should we design using mass timber?

• Construction materials account for 11% of global CO₂ emissions
• Concrete is the second used material after water
• We as declared a “Climate Emergency”
• Timber is the only sustainable construction material
Why should we design using mass timber?

WSP Commitment to Net Zero Carbon

We will halve the carbon footprint of our designs and advice by 2030.

WSP is the first to make this changemaking commitment.
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02 How we are proposing its usage

Modern Methods of Construction – CLT Hybrid Frames

Replacement of tradition composite deck floor slab construction with a CLT floor panels. The sustainable framing solution utilises the benefits of both materials.

Most efficient grid size is 9.0 x 13.5m, which limits CLT material wastage

MEP solution is not impacted by the change in floor slab

Design life of 50 years; European & BRE certification

Floor slab can provide up to REI 120.

Panel optimisation is key to an efficient and economic design in CLT.

Circa 42m³ of timber per trailer; 1 trailer contains 260m² of floor panels
02 How we are proposing its usage

Comparison study for a 7,000m² (75,350ft²) office floor plate

**CLT Hybrid**
160 CLT Slab on 490 Plate Girders

**Composite Deck Slab**
130 NWC Slab on 520 Plate Girders

**RC Frame**
325 RC Slab

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**Materials**

- **570 tonnes of steel beams**
- **1,140m³ of CLT slabs**
- **No concrete or wet trades**

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**Embodied carbon**

- **91 kg CO₂e / m²**
- **£48k offset payment**

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**Programme**

- **Sub - Lightest frame**
- **Super - 32 steels & 16 panels / day**

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**Material deliveries**

- **55No.**

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**Embodied carbon**

- **230 kg CO₂e / m²**
- **£123k offset payment**

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**Programme**

- **Sub – 35% heavier than CLT Hybrid**
- **Super – As CLT Hybrid, but concreting and curing added**

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**Material deliveries**

- **325No.**

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**Embodied carbon**

- **235 kg CO₂e / m²**
- **£125k offset payment**

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**Programme**

- **Sub – 80% heavier than CLT Hybrid**
- **Super – Slowest – number of elements, curing, back propping, etc. added**
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03 Retrofit
03 Retrofit
03 Retrofit

Current building

Proposed Demolition
03 Retrofit

Final Proposal

Upfront embodied carbon
140 kg CO$_2$e / m$^2$

Whole life embodied carbon
35 kg CO$_2$e / m$^2$
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04 Riverside New Build

Planning scheme

- Current design
  - 270 PT slab
  - 2.7m floor to ceiling

- 11 No. internal columns
  - Transfer pile caps over TW sewer

- Typical floor plate construction
  - Embodied carbon; 210 kg CO₂e / m²
  - Deliveries; 60No.
  - Offset Payment; £22k

- Substructure
  - Worst case column 14.0MN
  - General column 12.0MN

- L2 transfer beam
  - Column loads 4.0MN
04 Riverside New Build

New Client’s requirements:
- 500 kg CO₂e / m²
- 55 kWh / m²

Current design:
- 160 CLT slab on 490 steel beams
- MEP through cellular beam penetrations
- Floor to ceiling maintained / improved

- 7 No. internal columns; 4No. less
- No transfer pile caps over TW sewer

Typical floor plate construction:
- Embodied carbon; 50% less
- Deliveries; 75% less
- Carbon Offset Payment; 50% less

Substructure:
- Worst case column 15% saving
- General column 25% saving

L2 transfer beam:
- Column loads 40% saving

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SCI P354 Response
Factors
- Offices < 8.0
- Labs < 4.0
- Hospital wards < 2.0

CLT Hybrid Option
- Generally less than 4.0
- Areas up to 6.0

Response factor, RA3
- 6.6223
- 6.0705
- 5.5186
- 4.9568
- 4.4149
- 3.8630
- 3.3112
- 2.7593
- 2.2074
- 1.6556
- 1.1037
- 0.5519
- 0.0000

04 Riverside New Build
Client’s FAQs; Floor Vibration

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— **BCO Guidance**
  — S&C - On-site level difference $45 \text{ dB } D_{nT,w}$ (Lab rating no less than $49 \text{ dB } R_w$)
  — Fit-out - On-site level difference $48 \text{ dB } D_{nT,w}$ (Lab rating no less than $52 \text{ dB } R_w$)
04 Riverside New Build

Client’s FAQs; Fire

4 Compliance flow chart for Building Regulation B3(1)

Figure 4.1 – Compliance roadmap flow chart for MTTC in England

Extract from STA - Volume 6 Fire Safety - Mass Timber Compliance (October 2020)
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05 Major Project

A number of grid configurations and structural systems have been explored in order to investigate the embodied carbon, overall structural quantities, and structural depths of various floor systems.

Grid options 01 to 04 incorporate cellular openings (300 to 400mm diameter, spaced at 750mm centres) in the steel beams to allow MEP services to distribute between the structural bays.

However, option 05 allows for the MEP services to run below the beams as the structure is too shallow to incorporate meaningful web penetrations.

Structural System C, which incorporates mass timber beams, requires early coordination (Stage 2+5) to ensure that MEP distribution and associated penetrations through the laminated veneer lumber (LVL) beams are incorporated in the design.

The use of underfloor air distribution systems is assumed. In order for MEP distribution through the beams to be nominal.

Grid Configurations

<table>
<thead>
<tr>
<th>Option</th>
<th>Dimensions</th>
<th>MEP Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>16.5 x 12.0 m</td>
<td>one column per 190 m²</td>
</tr>
<tr>
<td>02</td>
<td>16.5 x 9.0 m</td>
<td>one column per 149 m²</td>
</tr>
<tr>
<td>03</td>
<td>12.0 x 9.0 m</td>
<td>one column per 108 m²</td>
</tr>
<tr>
<td>04</td>
<td>9.0 x 9.0 m</td>
<td>one column per 81 m²</td>
</tr>
<tr>
<td>05</td>
<td>7.5 x 7.5 m</td>
<td>one column per 56 m²</td>
</tr>
</tbody>
</table>

Structural Systems

A 150mm LWC composite deck slab on steel beams

B 160mm cross-laminated timber (CLT) panels on steel beams

C 160mm CLT panels on laminated veneer lumber (LVL) secondary beams and steel primary beams
# 05 Major Project

## Comparative Data

<table>
<thead>
<tr>
<th>Structural System A</th>
<th>Structural System B</th>
<th>Structural System C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grid Spacing</strong></td>
<td><strong>Secondary Beam Span</strong></td>
<td><strong>Embodied Carbon</strong></td>
</tr>
<tr>
<td>A-01</td>
<td>6.5 x 12.0</td>
<td>16.5</td>
</tr>
<tr>
<td>A-02</td>
<td>16.5 x 12.0</td>
<td>16.5</td>
</tr>
<tr>
<td>A-03</td>
<td>12.0 x 9.0</td>
<td>12.0</td>
</tr>
<tr>
<td>A-04</td>
<td>9.0 x 9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>A-05</td>
<td>7.5 x 7.5</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>Structural System B</strong></td>
<td><strong>160-CLT on steel beams</strong></td>
<td><strong>160-CLT on wood beams</strong></td>
</tr>
<tr>
<td>B-01</td>
<td>16.5 x 12.0</td>
<td>16.5</td>
</tr>
<tr>
<td>B-02</td>
<td>16.5 x 9.0</td>
<td>16.5</td>
</tr>
<tr>
<td>B-03</td>
<td>12.0 x 9.0</td>
<td>12.0</td>
</tr>
<tr>
<td>B-04</td>
<td>9.0 x 9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>B-05</td>
<td>7.5 x 7.5</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>Structural System C</strong></td>
<td><strong>160-CLT on wood beams &amp; steel beams</strong></td>
<td><strong>Steel beams only</strong></td>
</tr>
<tr>
<td>C-01</td>
<td>16.5 x 12.0</td>
<td>12.0</td>
</tr>
<tr>
<td>C-02</td>
<td>16.5 x 9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>C-03</td>
<td>12.0 x 9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>C-04</td>
<td>9.0 x 9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>C-05</td>
<td>7.5 x 7.5</td>
<td>7.5</td>
</tr>
</tbody>
</table>

**NOTES:**
- LESS 2020
- Embedded Carbon
- Mass timber option
- Beam Continuity
- LESS kg(CO2)/m² for slab and beams
- Includes carbon sequestration for mass timber elements
- Option C-02 makes use of mass timber for both secondary and primary beams
- Continuity of primary beams at column positions can further decrease carbon and mass.

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**WSP**

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Option 1
12.0 x 9.0m

Notes:
1. Floor slab construction can be either:
   - 130 LWC composite deck acting as permanent formwork (secondary beams at 3.0m centres)
   - 160 CLT L5s slab (secondary beams at 4.5m centres)
2. UFAD system in the 400mm zone and additional MEP distribution through the cellular penetrations in the steel beams.
3. Intumescent paint to steel beams to provide REI120.
4. Note that the sheered board included with the CLT deck accounts for 35 kgCO₂e/m².

<table>
<thead>
<tr>
<th>Data</th>
<th>1A Composite deck</th>
<th>1B CLT deck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Steel Mass</td>
<td>36</td>
<td>25</td>
</tr>
<tr>
<td>Overall Structural Mass</td>
<td>287</td>
<td>130</td>
</tr>
<tr>
<td>Embodied Carbon*</td>
<td>147</td>
<td>95</td>
</tr>
</tbody>
</table>

* embodied carbon values for timber based on How to calculate embodied carbon - iStrucE v2.0, due Spring 2022
** including sequestration
Option 2
9.0 x 9.0m

Notes:
1. Floor slab construction can be either:
   - 130 LWC composite deck acting as permanent formwork (secondary beams at 3.0m centres)
   - 160 CLT L5s slab (secondary beams at 4.5m centres)
2. UFAD system in the 400mm zone and additional MEP distribution through the cellular penetrations in the steel beams.
3. Intumescent paint to steel beams to provide RE120.
4. Note that the screed board included with the CLT deck accounts for 38 kgCO2e/m².

Data:

<table>
<thead>
<tr>
<th></th>
<th>2A Composite deck</th>
<th>2B CLT deck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Steel Mass</td>
<td>29 kg/m²</td>
<td>23 kg/m²</td>
</tr>
<tr>
<td>Overall Structural Mass</td>
<td>280 kg/m²</td>
<td>135 kg/m²</td>
</tr>
<tr>
<td>Embodied Carbon*</td>
<td>129 kgCO2e/m²</td>
<td>88 kgCO2e/m²</td>
</tr>
</tbody>
</table>

* embodied carbon values for timber based on how to calculate embedded carbon - fBunde v2.0, due Spring 2022
** including sequestration
05 Major Project - Floor Plate Options

Option 3A, 3B
7.5 x 7.5m

Notes:
1. Floor slab construction can be either:
   - 130 LWC composite deck acting as permanent formwork (secondary beams at 2.5m centres)
   - 160 CLT L5 slab (secondary beams at 3.75m centres)
2. Steel beams have no cellular penetrations.
3. MEP distribution in the 400mm zone above the floor slab.
4. Intumescent paint to steel beams to provide REH120.
5. Note that the screed board included with the CLT deck accounts for 38 kgCO₂e/m².

Data:

<table>
<thead>
<tr>
<th></th>
<th>3A Composite deck</th>
<th>3B CLT deck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Steel Mass</td>
<td>21</td>
<td>30</td>
</tr>
<tr>
<td>Overall Structural Mass</td>
<td>272</td>
<td>143</td>
</tr>
<tr>
<td>Embodied Carbon*</td>
<td>108</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-19**</td>
</tr>
</tbody>
</table>

* embodied carbon values for timber based on New to calculate embodied carbon - /Sheätz v2.6, AIA Spring 2022
** including sequestration
05 Major Project - Floor Plate Options

Embodied Carbon

LETI 2030 Targets

- Project: 350 kgCO₂e/m²
- Structure: 228
- Superstructure: 168

Floor Structure

- Composite Deck:
  - 12.0 x 9.0 Structural Grid: 147
  - 9.0 x 9.0 Structural Grid: 129
  - 7.5 x 7.5 Structural Grid: 108
- CLT Deck:
  - 12.0 x 9.0 Structural Grid: 95
  - 9.0 x 9.0 Structural Grid: 88
  - 7.5 x 7.5 Structural Grid: 107
- Full Timber:
  - 12.0 x 9.0 Structural Grid: 41

NOTE: Also refer to WSP Net Zero Nomenclature presentation.

NOTE: Carbon sequestration is not included in these values.
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06 The next steps
06 The next steps

— Working with the CTBUH, insurance industry and local authorities to make receiving assurance & approval simpler

— Lobby for fire test data to be made available to the industry

— Working with industry to increase the amount of recycled steel elements

— Exploring options for the two elements to act compositely
Thanks for listening

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