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

Dan Hagan
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CTBUH 2022
Steel-Timber Conference

Council on Tall Buildings and Urban Habitat

Reducing Carbon Footprint via Smaller & Lighter Structural Grids

Presentation to CTBUH Steel-Timber Hybrid Buildings Conference, Chicago
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Image courtesy of 6a Architects

Introductions

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01

Why should we design using mass timber?

02

How we are proposing its usage

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Riverside New Build Case Study

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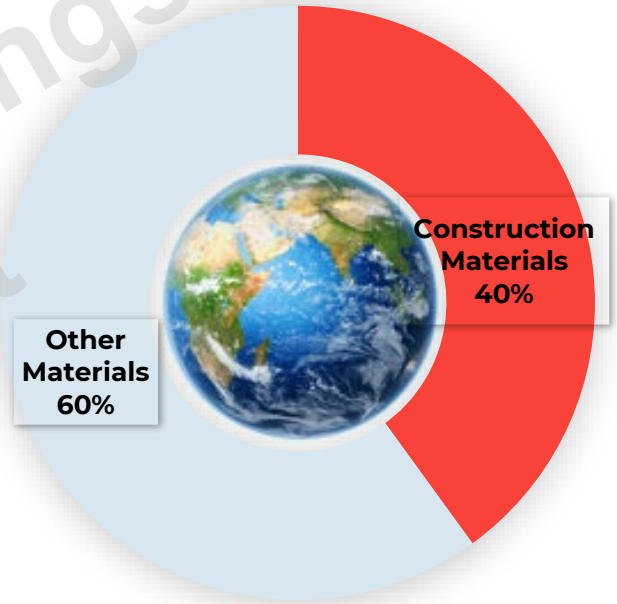
01 Why should we design using mass timber?

- Construction materials account for 11% of global CO_2 emissions
- Concrete is the second used material after water
- We as declared a “Climate Emergency”
- Timber is the only sustainable construction material



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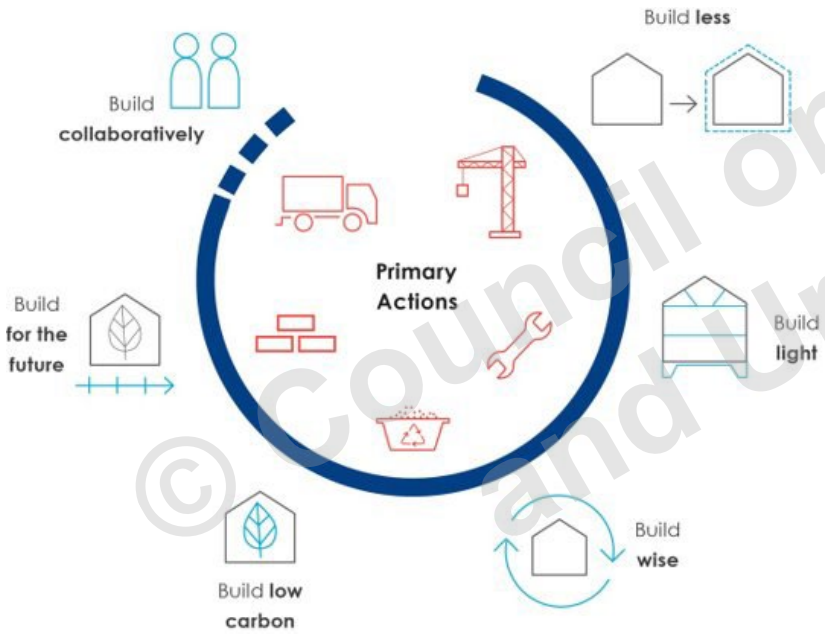
WSP Commitment to Net Zero Carbon

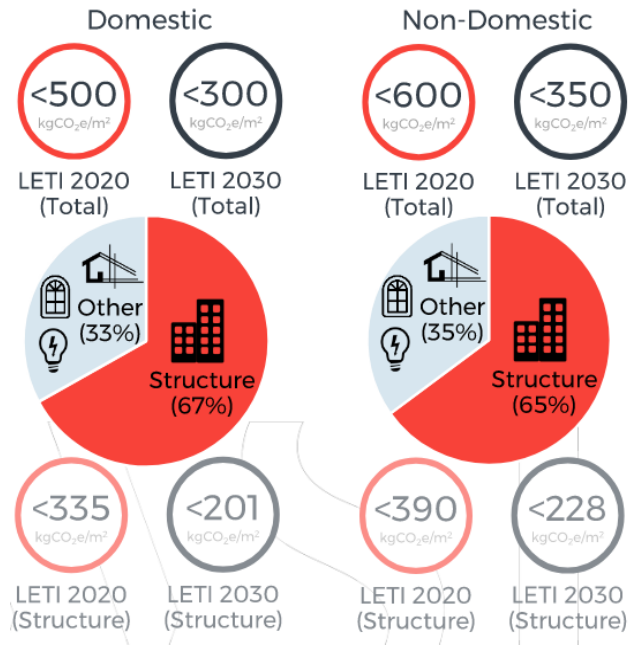
GOING NET ZERO AT WSP

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

WSP is the first to make this changemaking commitment.



© LETI



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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 42m^3 of timber per trailer; 1 trailer contains 260m^2 of floor panels

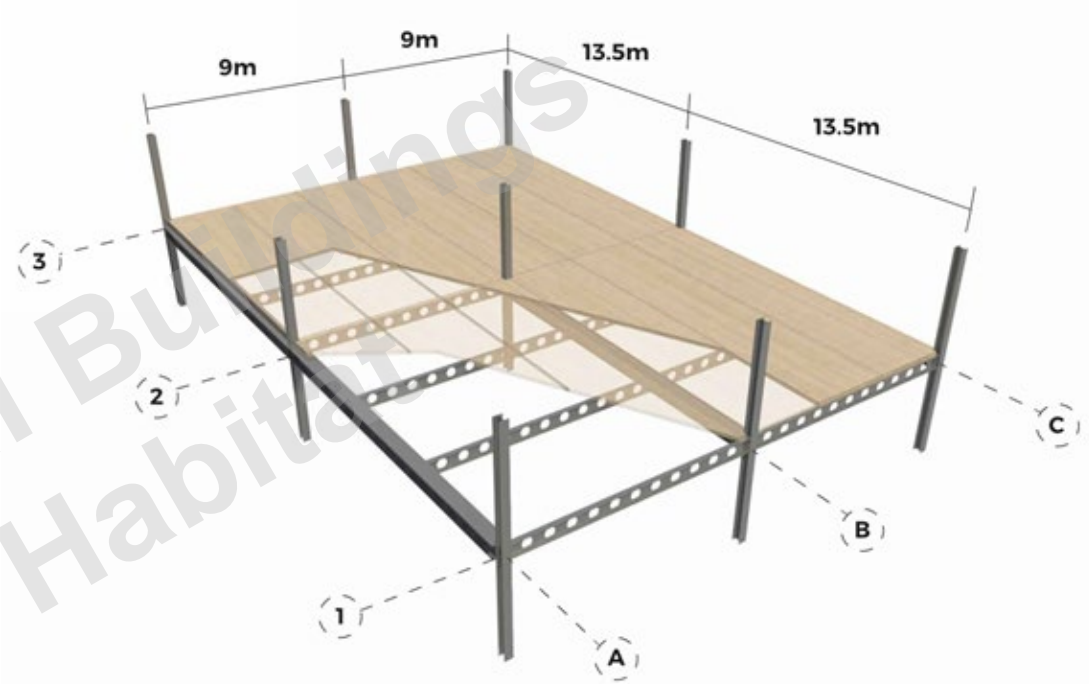


Figure 1 - Typical structural grid

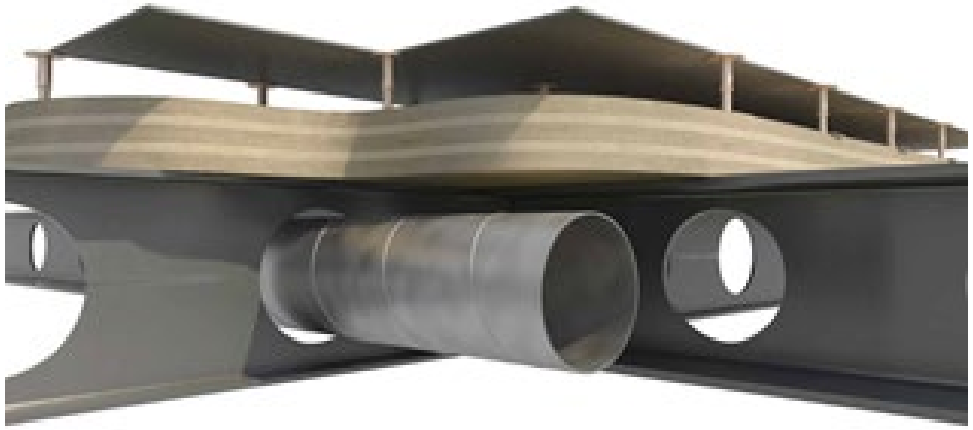
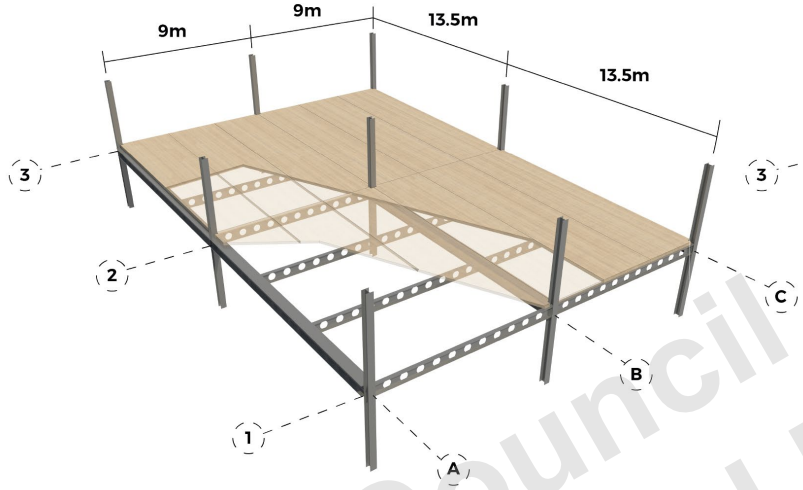


Figure 2 - Typical section through floor

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



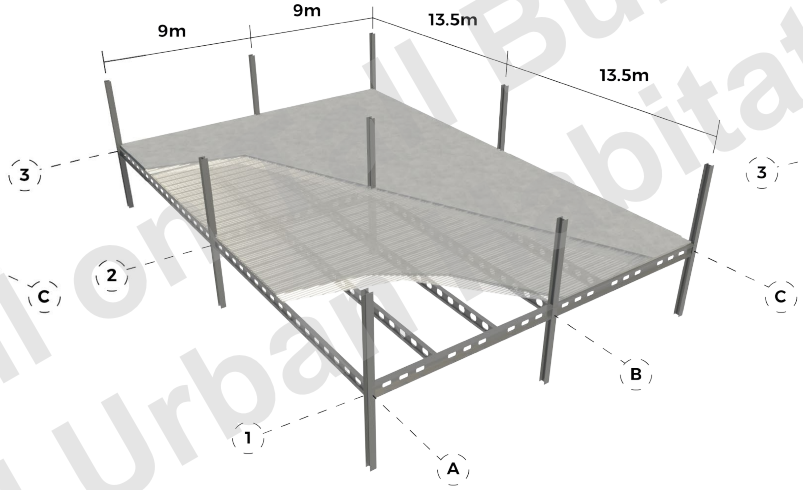
Materials
570 tonnes of steel beams
1,140m³ of CLT slabs
No concrete or wet trades

Material deliveries
55No.

Embodied carbon
91 kg CO_2e / m²
£48k offset payment

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

Composite Deck Slab
130 NWC Slab on 520 Plate Girders



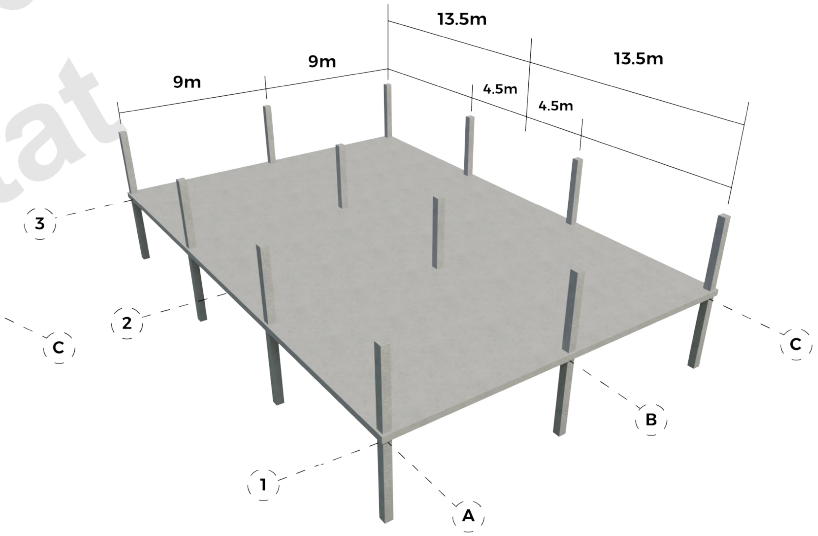
855m³ of concrete
22 tonnes of reinforcement
570 tonnes of steel beams
7,000m² of metal decking

140No.

230 kg CO_2e / m²
£123k offset payment

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

RC Frame
325 RC Slab



2,305m³ of concrete
890 tonnes of reinforcement
Excludes formwork

325No.

235 kg CO_2e / m²
£125k offset payment

Sub – 80% heavier than CLT Hybrid
Super – Slowest – number of elements, curing, back propping,

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03 Retrofit

03 Retrofit

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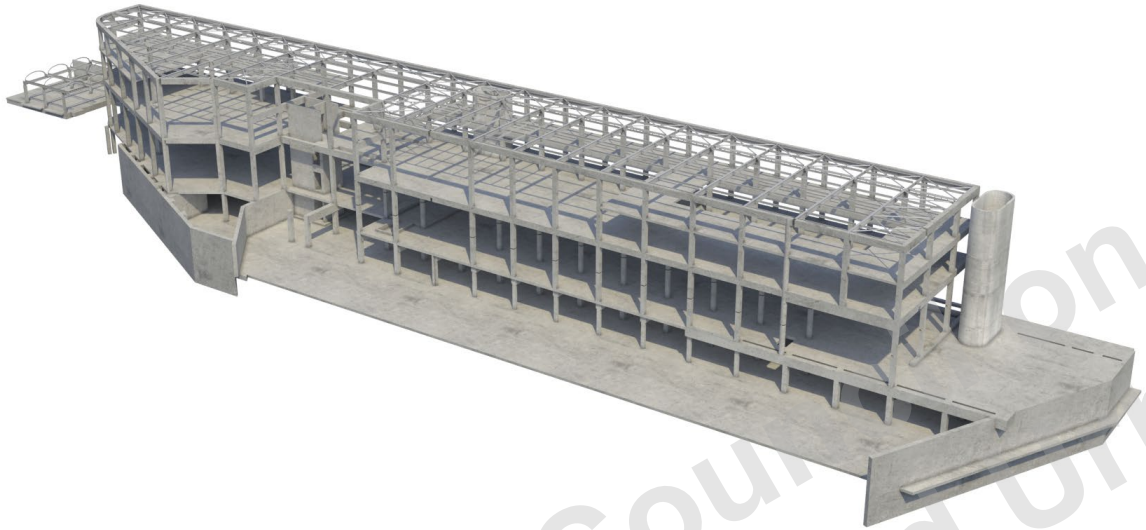
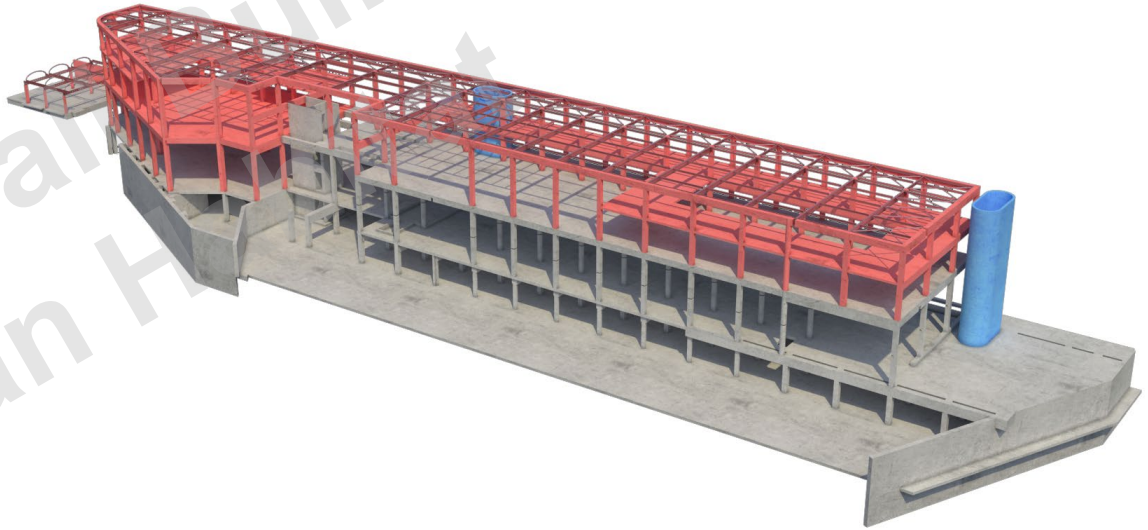
03 Retrofit

Current building



Proposed Demolition



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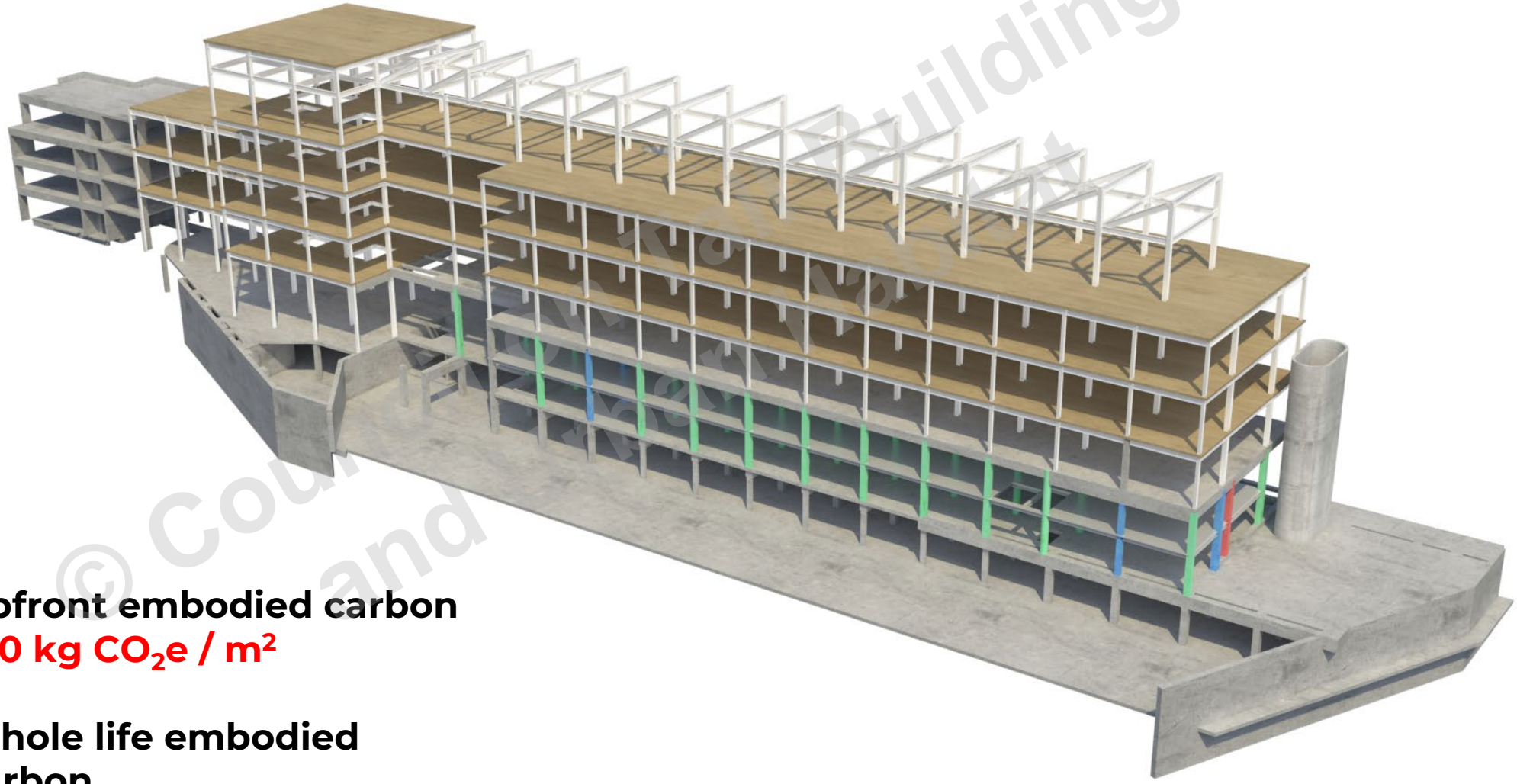
03 Retrofit

Final Proposal



Upfront embodied carbon
140 kg CO_2e / m^2

Whole life embodied carbon
35 kg CO_2e / m^2

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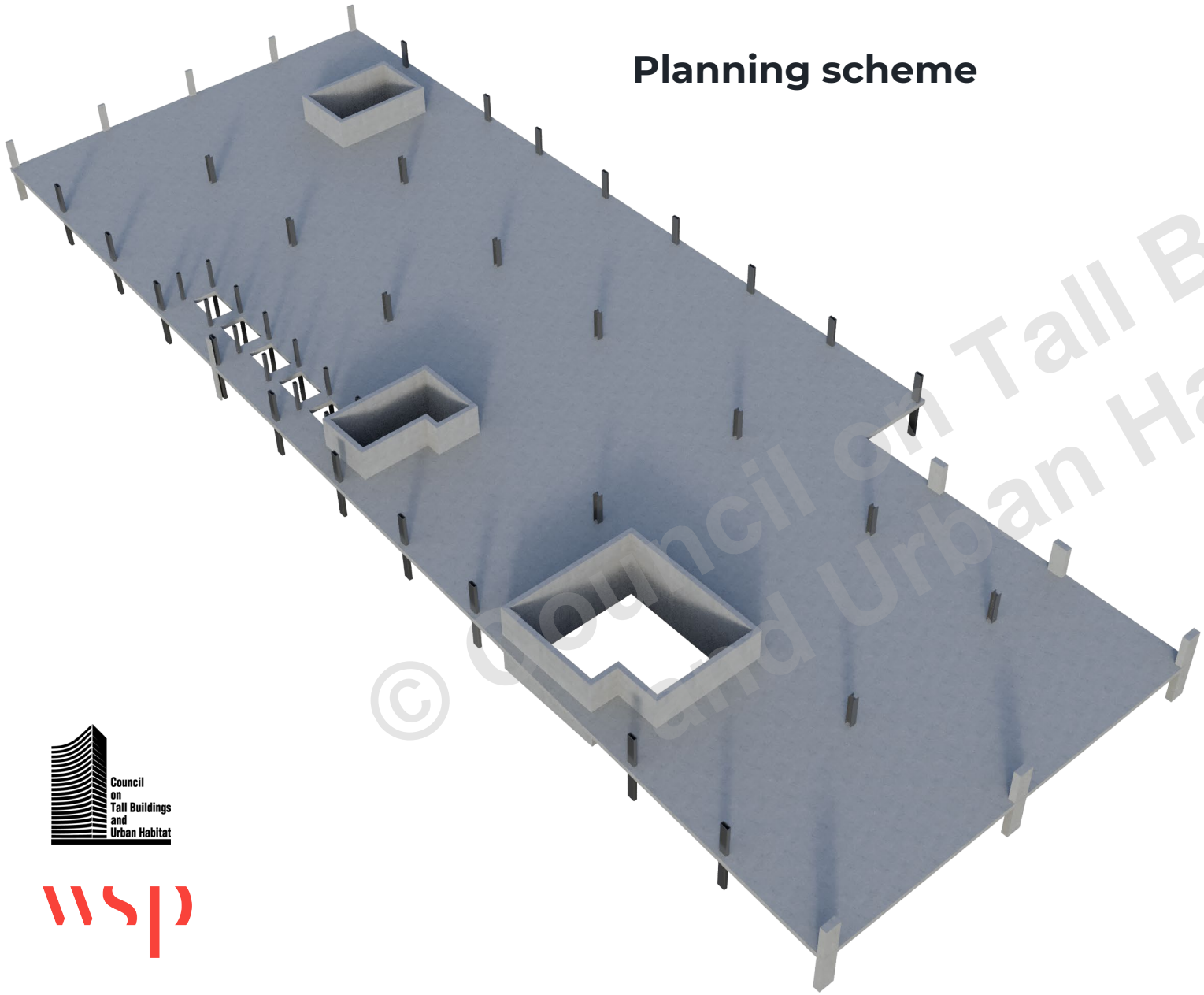
04 Riverside New Build



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 CO_2e / m^2*
  - *Deliveries; 60No.*
  - *Offset Payment; £22k*
- Substructure
  - *Worst case column 14.0MN*
  - *General column 12.0MN*
- L2 transfer beam
  - *Column loads 4.0MN*

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04 Riverside New Build

New Client's requirements:

- **500 kg CO_2e / m^2**
- **55 kWh / m^2**

- 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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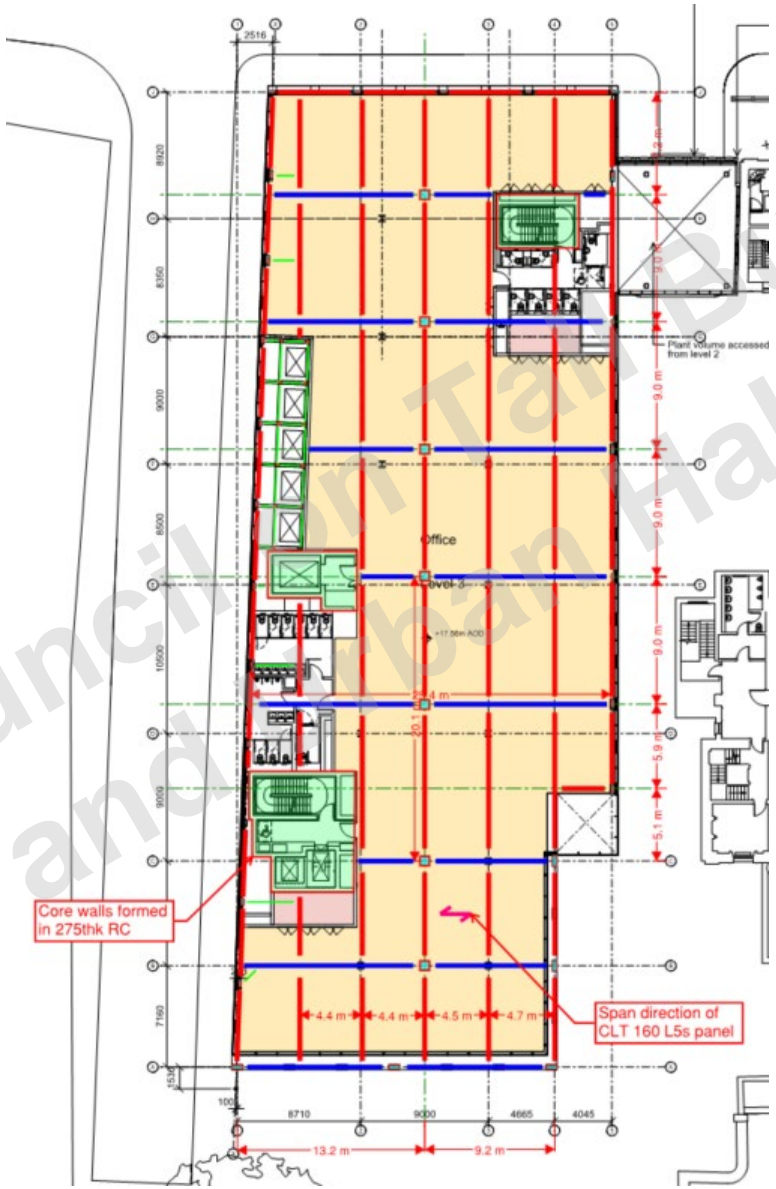
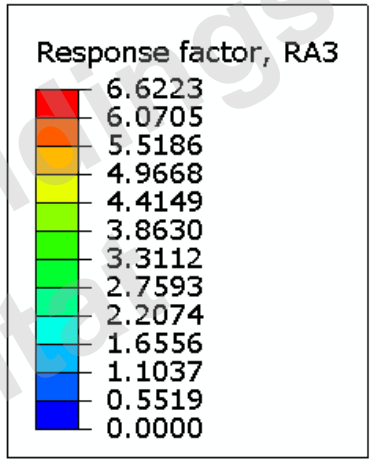
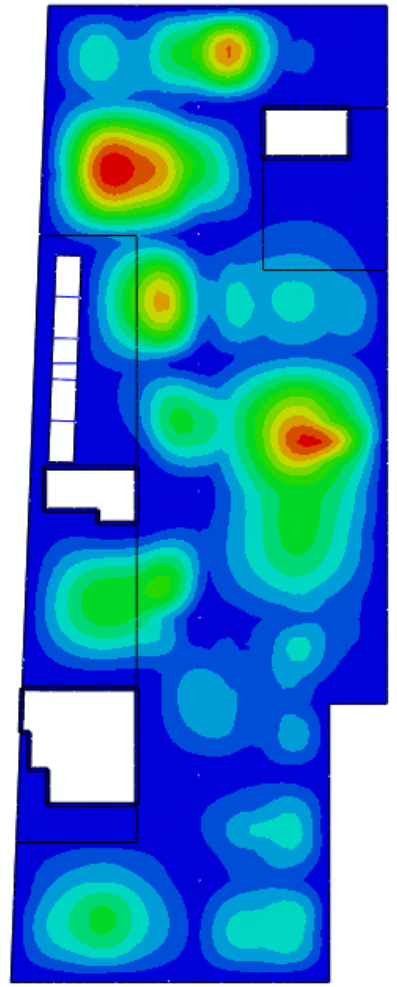
04 Riverside New Build

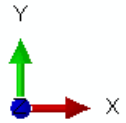
Client's FAQs; Floor Vibration

- 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*









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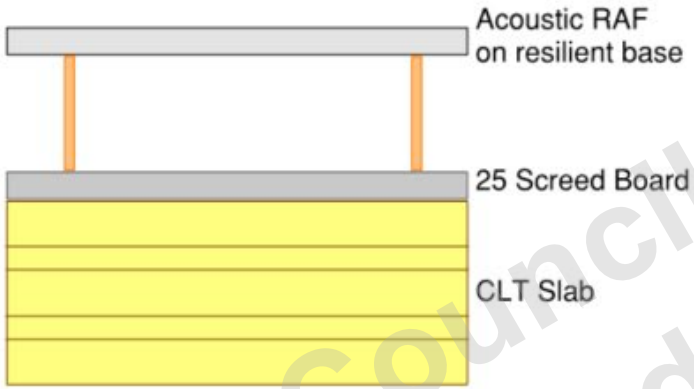
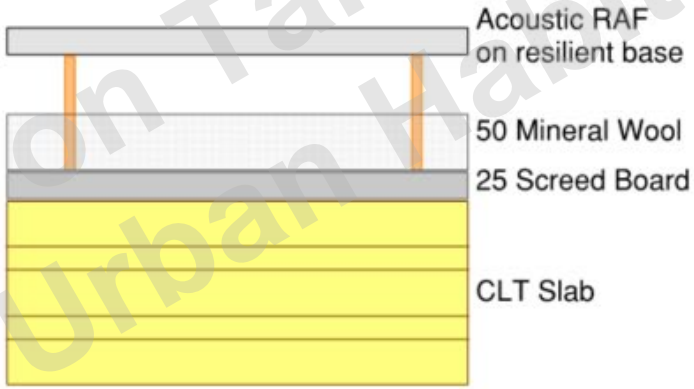
04 Riverside New Build

Client's FAQs; Acoustics

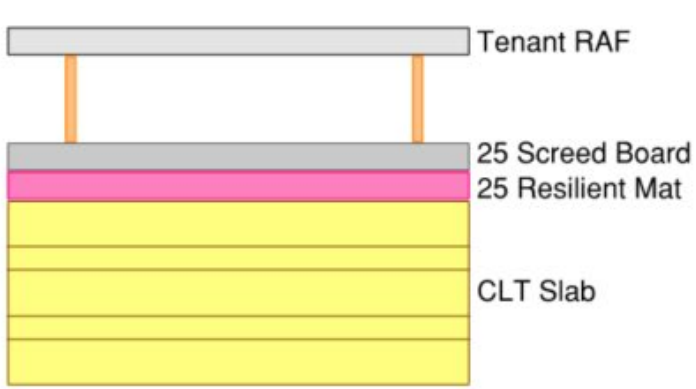
- BCO Guidance
  - *S&C - On-site level difference **45 dB $D_{nT,w}$** (Lab rating no less than **49 dB R_w**)*
  - *Fit-out - On-site level difference **48 dB $D_{nT,w}$** (Lab rating no less than **52 dB R_w**)*



1. < BCO



2. BCO
Acoustic RAF installed



3. BCO
Tenant installs RAF

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04 Riverside New Build

Client's FAQs; Fire

4 Compliance flow chart for Building Regulation B3(1)

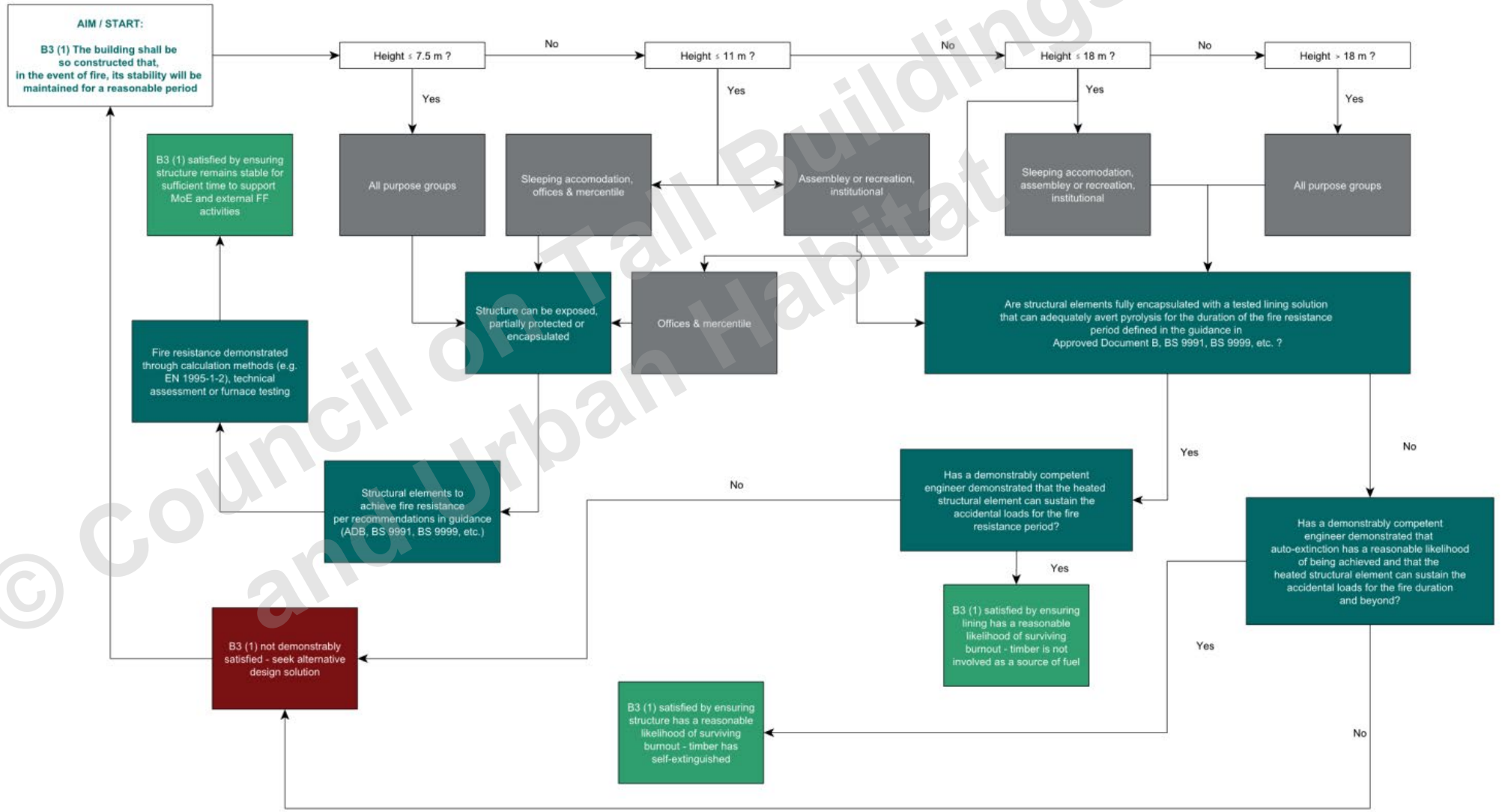

Figure 4-1 – Compliance roadmap flow chart for MTPC in England

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.

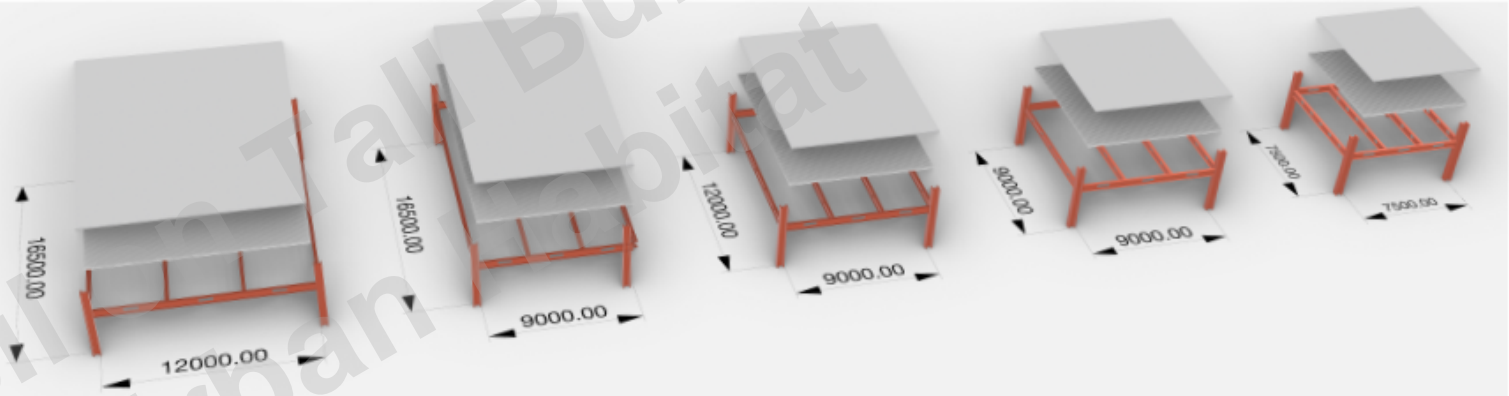
However, option 05 allows for the MEP services to run below the beams as the structure is too shallow to incorporate meaningful web penetrations.

Structural System C, which incorporates mass timber beams, requires early coordination (Stage 2+/3) to ensure that MEP distribution and associated penetrations through the laminated veneer lumber (LVL) beams are incorporated in the design.

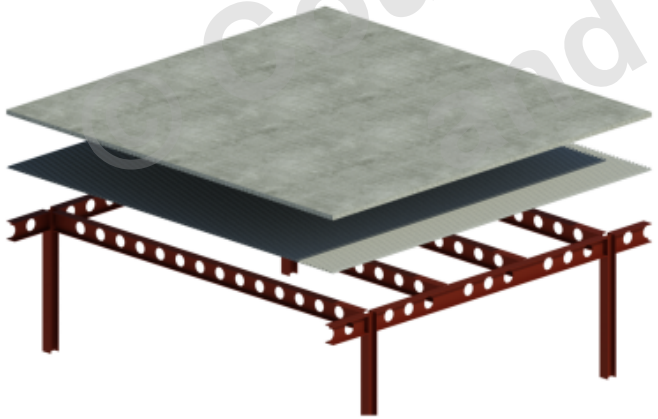
The use of underfloor air distribution systems is assumed, in order for MEP distribution through the beams to be nominal.

Grid Configurations

01	16.5 x 12.0 m	/	one column per 198 m²
02	16.5 x 9.0 m	/	one column per 149 m²
03	12.0 x 9.0 m	/	one column per 108 m²
04	9.0 x 9.0 m	/	one column per 81 m²
05	7.5 x 7.5 m	/	one column per 56 m²



Structural Systems



A 130mm 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

		Grid Spacing m	Secondary Beam Span m	Embodied Carbon kgCO₂e/m²	Structural Steel Mass kg/m²	Structural Floor Mass kg/m²	Structural Depth (slab and beam) mm	One column per m²
Structural System A	A-01	16.5 x 12.0	16.5	187	51	302	750	198
130 LWC composite deck	A-02	16.5 x 9.0	16.5	162	41	292	700	149
on steel beams	A-03	12.0 x 9.0	12.0	140	32	283	650	108
	A-04	9.0 x 9.0	9.0	135	30	281	600	81
	A-05	7.5 x 7.5	7.5	122	25	276	430	56
Structural System B	B-01	16.5 x 12.0	16.5	196	99	211	750	198
160 CLT on steel beams	B-02	16.5 x 9.0	16.5	220	109	220	700	149
	B-03	12.0 x 9.0	12.0	62	46	157	650	108
	B-04	9.0 x 9.0	9.0	26	31	143	600	81
	B-05	7.5 x 7.5	7.5	54	42	154	520	56
Structural System C	C-01	16.5 x 12.0	12.0					
160 CLT on LVL beams &	C-02	16.5 x 9.0	9.0	57	55	188	700	149
steel beams	C-03	12.0 x 9.0	9.0	-35	18	152	650	108
	C-04	9.0 x 9.0	9.0	-48	13	147	600	81
	C-05	7.5 x 7.5	7.5	-91	-	143	520	56

NOTES:

- LETI 2030
- Embodied Carbon
- Mass timber option
- Beam Continuity

137 kgCO₂e/m² for slab and beams
includes carbon sequestration for mass timber elements
option C-05 makes use of mass timber for both secondary and primary beams
continuity of primary beams at column positions can further decrease carbon and mass

Structural System A

Structural System B

Structural System C

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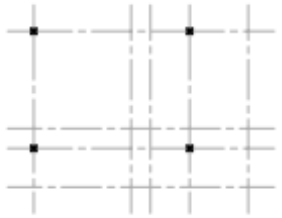
05 Major Project - Floor Plate Options

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 screed board included with the CLT deck accounts for 38 $kgCO_2e/m^2$.

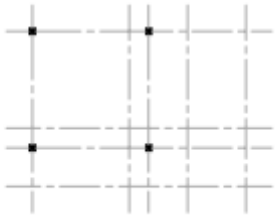
Data:	1A Composite deck	1B CLT deck	
Structural Steel Mass	36	25	kg/m^2
Overall Structural Mass	287	138	kg/m^2
Embodied Carbon*	147	95 (-29 **)	$kgCO_2e/m^2$

* embodied carbon values for timber based on *How to calculate embodided carbon - IStructE v2.0*, due Spring 2022

** including sequestration

05 Major Project - Floor Plate Options

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 REI120.
4. Note that the screed board included with the CLT deck accounts for 38 $kgCO_2e/m^2$.

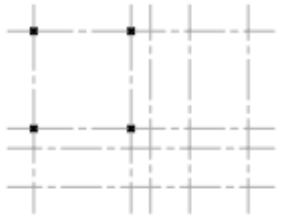
Data:	2A **Composite deck**	2B **CLT deck**	
Structural Steel Mass	29	23	kg/m^2
Overall Structural Mass	280	135	kg/m^2
Embodied Carbon*	129	88 (-36 **)	$kgCO_2e/m^2$

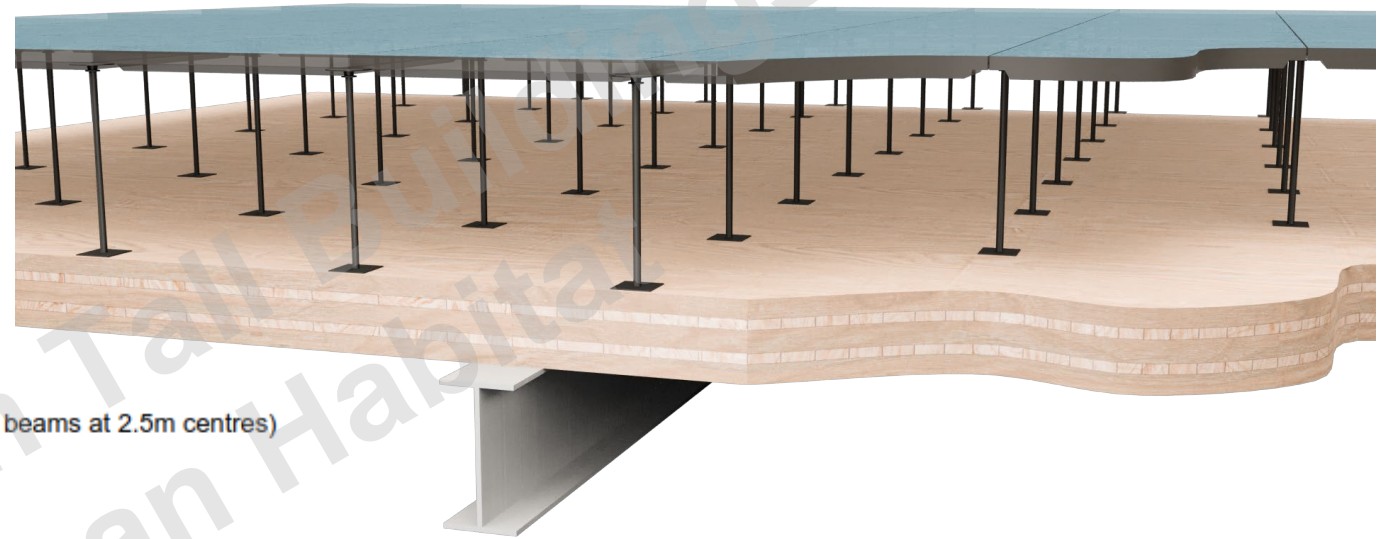
* embodied carbon values for timber based on *How to calculate embodided carbon - IStructE v2.0*, due Spring 2022

** 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 L5s 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 REI120.
5. Note that the screed board included with the CLT deck accounts for 38 $kgCO_2e/m^2$.

Data:	3A **Composite deck**	3B **CLT deck**	
Structural Steel Mass	21	30	kg/m^2
Overall Structural Mass	272	143	kg/m^2
Embodied Carbon*	108	107 (-19 **)	$kgCO_2e/m^2$

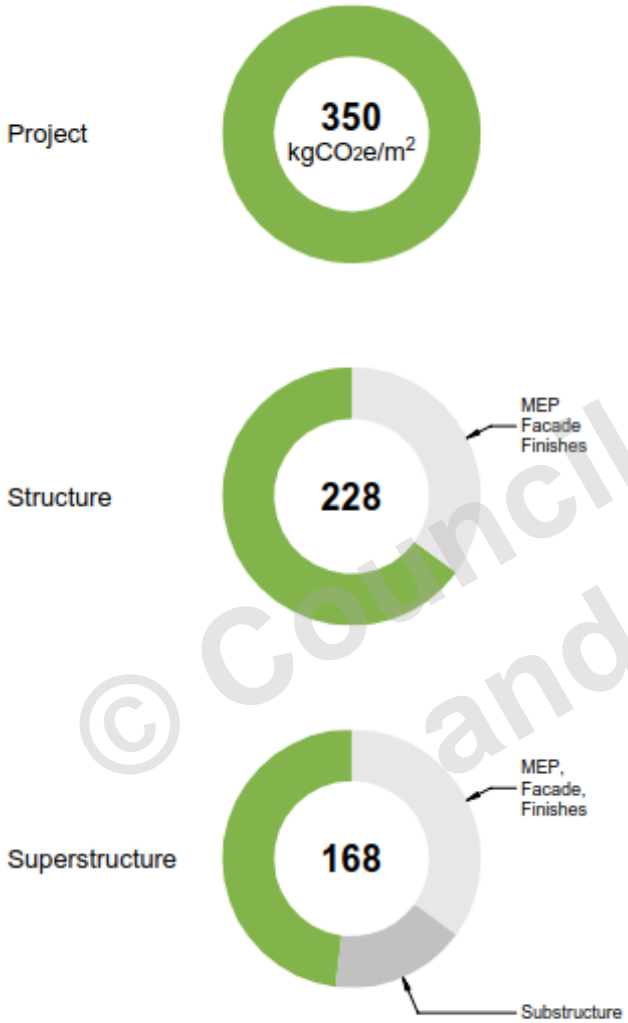
* embodied carbon values for timber based on *How to calculate embodided carbon - IStructE v2.0*, due Spring 2022

** including sequestration

05 Major Project - Floor Plate Options

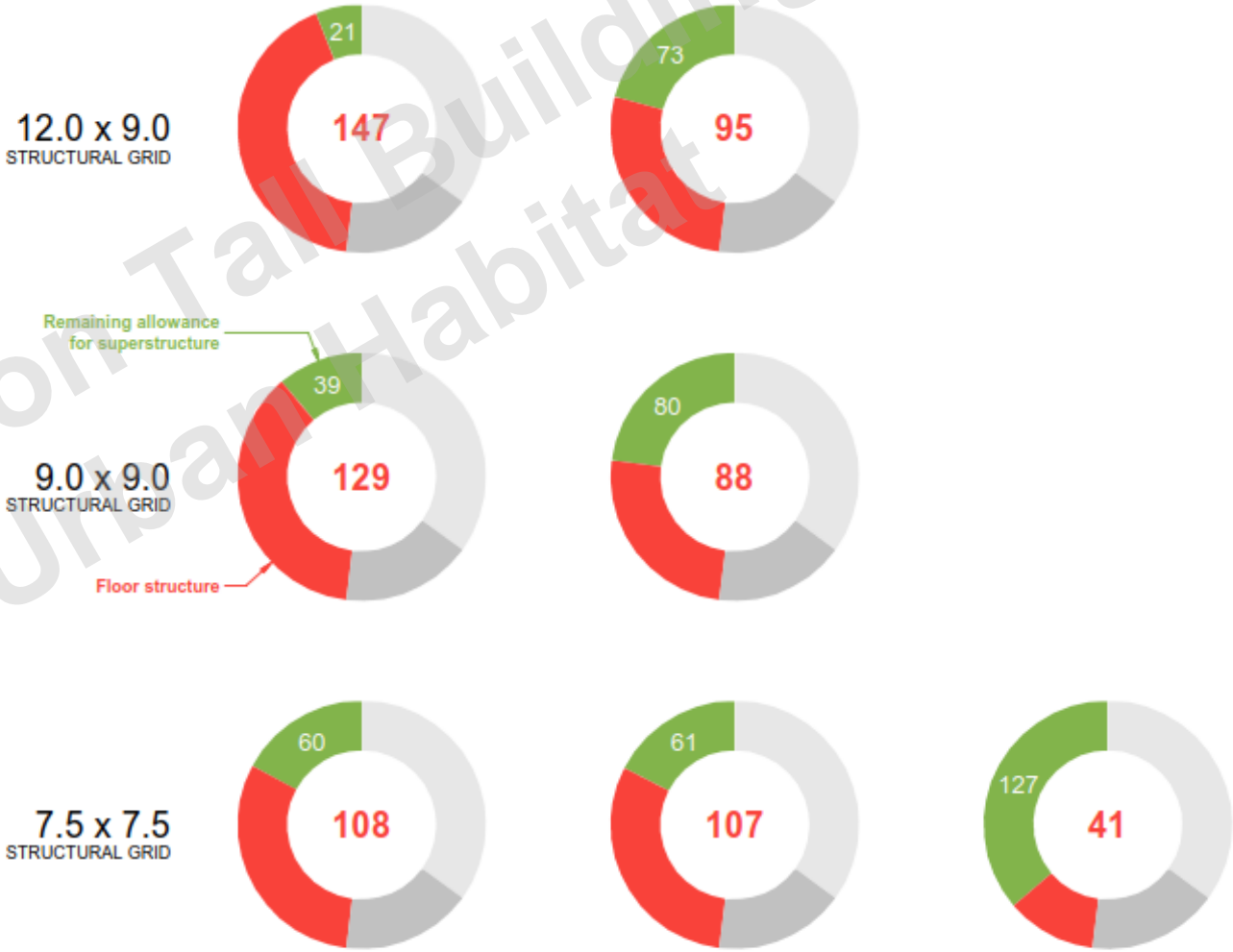
Embodied Carbon

LETI 2030 Targets



NOTE: Also refer to WSP Net Zero Nomenclature presentation.

Floor Structure



NOTE: Carbon sequestration is not included in these values.

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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

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Image courtesy of 6a Architects

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Thanks for listening

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