Tall Timber in 2023: Current State and Future Potential

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15 May 2023

Council on Tall Buildings and Urban Habitat

Council On Tall Buildings and Urban Habitat

ADVANCING SUSTAINABLE VERTICAL URBANISM

Founded in 1969.

Non-profit, multi-disciplinary, worldwide association focused on tall buildings and sustainable cities.

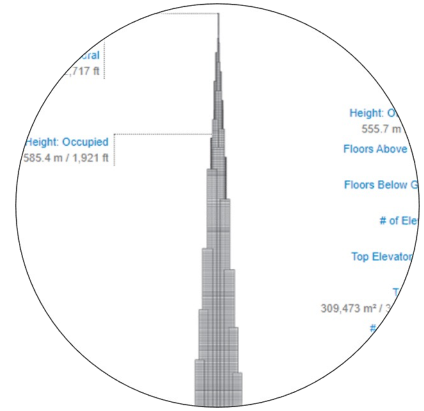
The CTBUH organizational member network includes 2,000,000+ individuals working in 10,000+ offices around the world.

Council on Tall Buildings and Urban Habitat

What We Do

Convene a Multi-Disciplinary Industry

Share Best Practice Information



Track and Report Tall Building Info & Data

Research Critical Industry Topics

Recognize Superior Urban Achievements

Advocate for Dense Urban Solutions

Understanding Mass Timber:

Structural Material Classifications

Structural Material Classification:

All-Timber Structures

All above-ground vertical, floor spanning, and lateral-force-resisting structural elements must be constructed from timber.

Structural Material Classification:

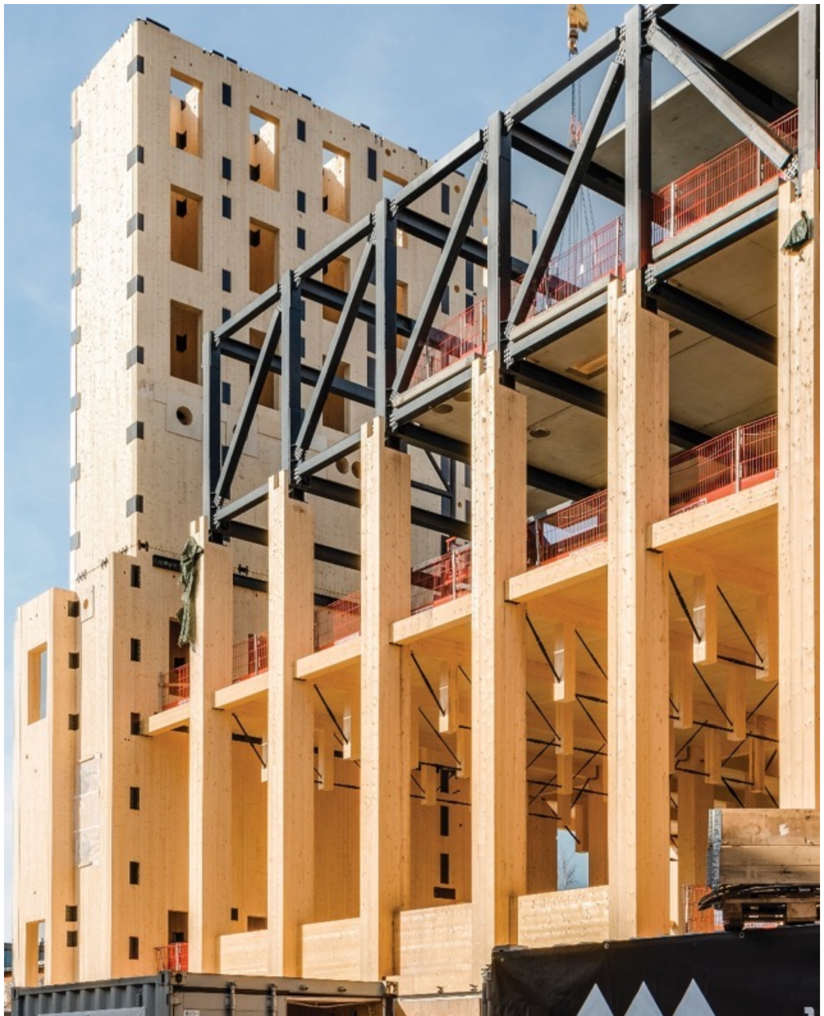
Concrete-Timber Hybrid Structures

All above-ground vertical, floor spanning, and lateral-force-resisting structural elements must be constructed from timber, concrete, or a combination of the two.

Structural Material Classification:

Steel-Timber Hybrid Structures

All above-ground vertical, floor spanning, and lateral-force-resisting structural elements must be constructed from timber, steel, or a combination of the two.



Structural Material Classification:

Concrete-Steel-Timber Hybrid Structures

All above-ground vertical, floor spanning, and lateral-force-resisting structural elements must be constructed from timber, steel, concrete, or a combination of the three.

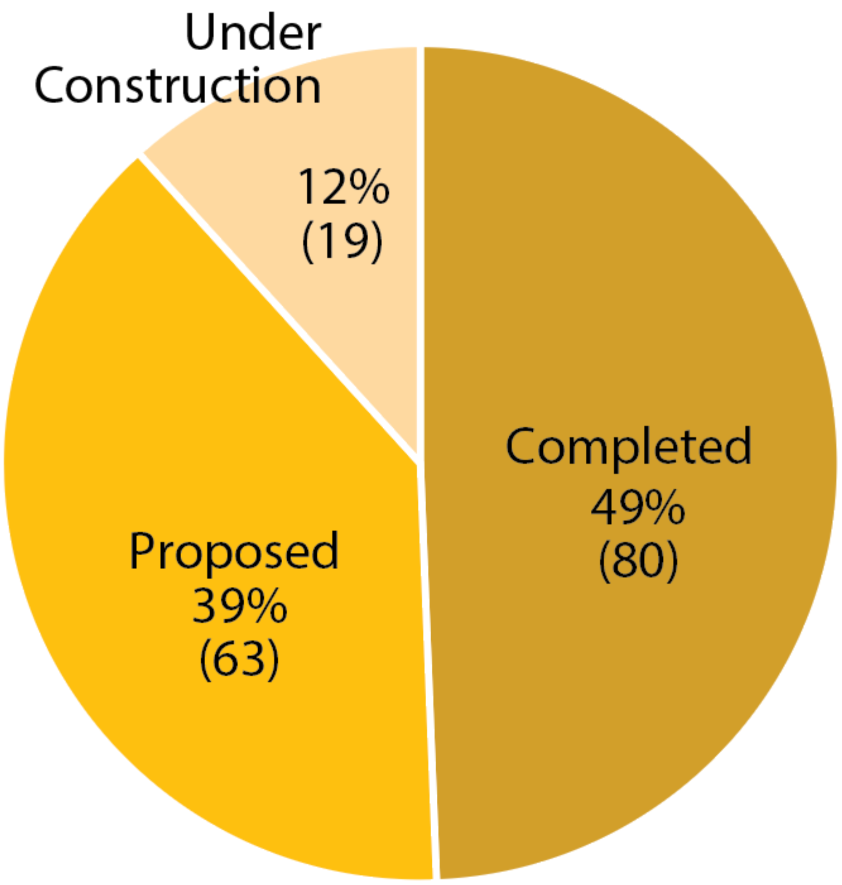
Tall Timber Global Audit

*All data as of March 2023

Tall Timber Global Audit:

Mass Timber Buildings, by Status

Proposed, under construction, and completed mass timber buildings, eight stories and higher.

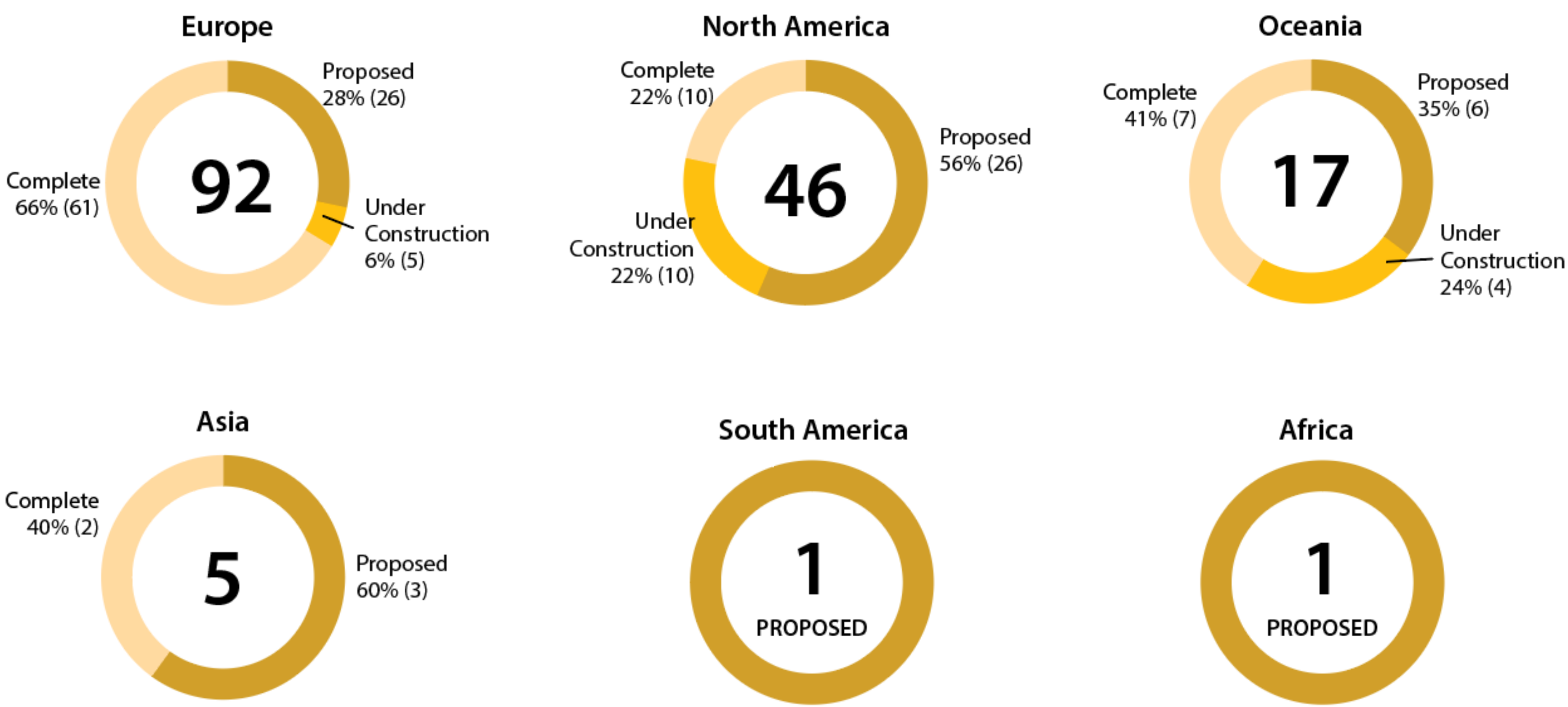


162 Projects Total

Tall Timber Global Audit:

Cross-Comparisons, by Region

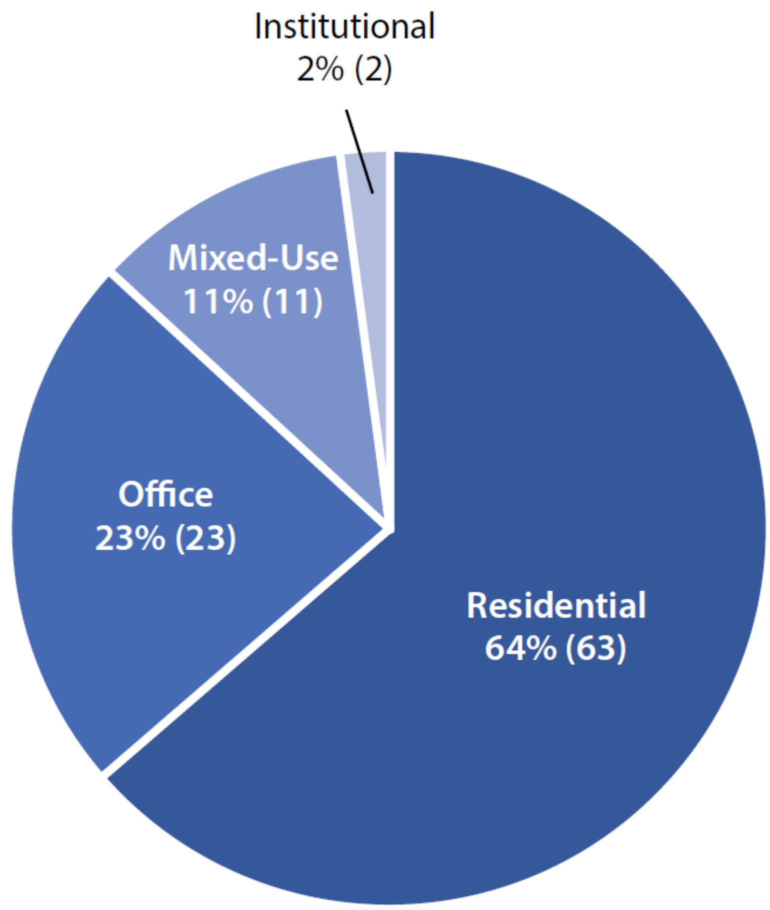
Proposed, under construction, and completed mass timber buildings, eight stories and higher, by region.



Tall Timber Global Audit:

Mass Timber Buildings, by Function

The number of under construction and completed mass timber buildings, eight stories and higher, broken down by function.

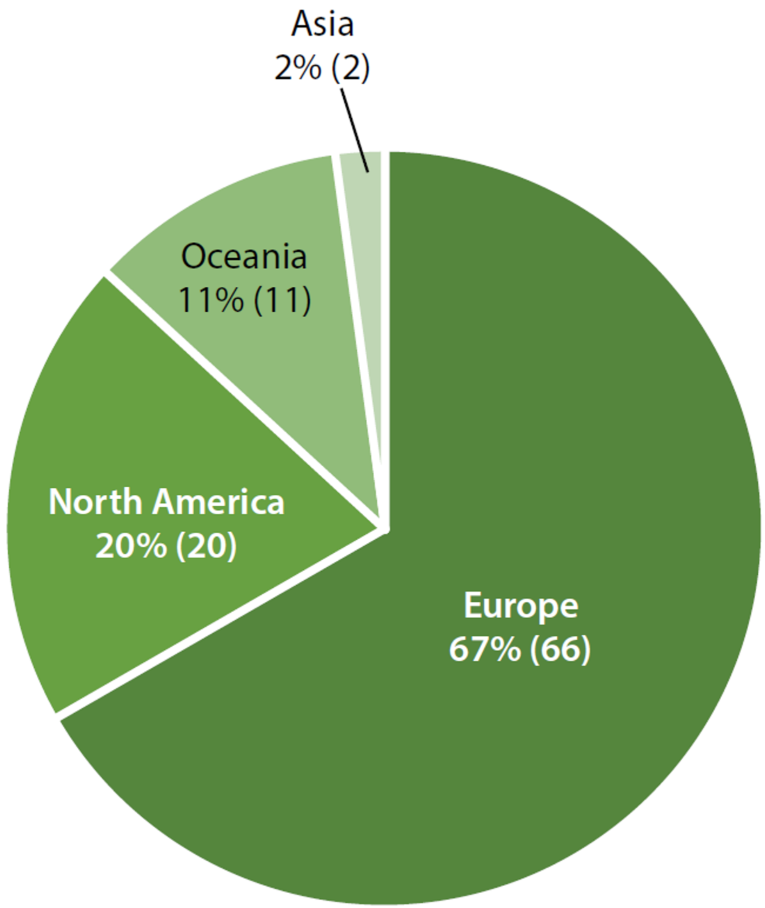


99 Projects Total

Tall Timber Global Audit:

Mass Timber Buildings, by Region

The number of under construction and completed mass timber buildings, eight stories and higher, broken down by region.

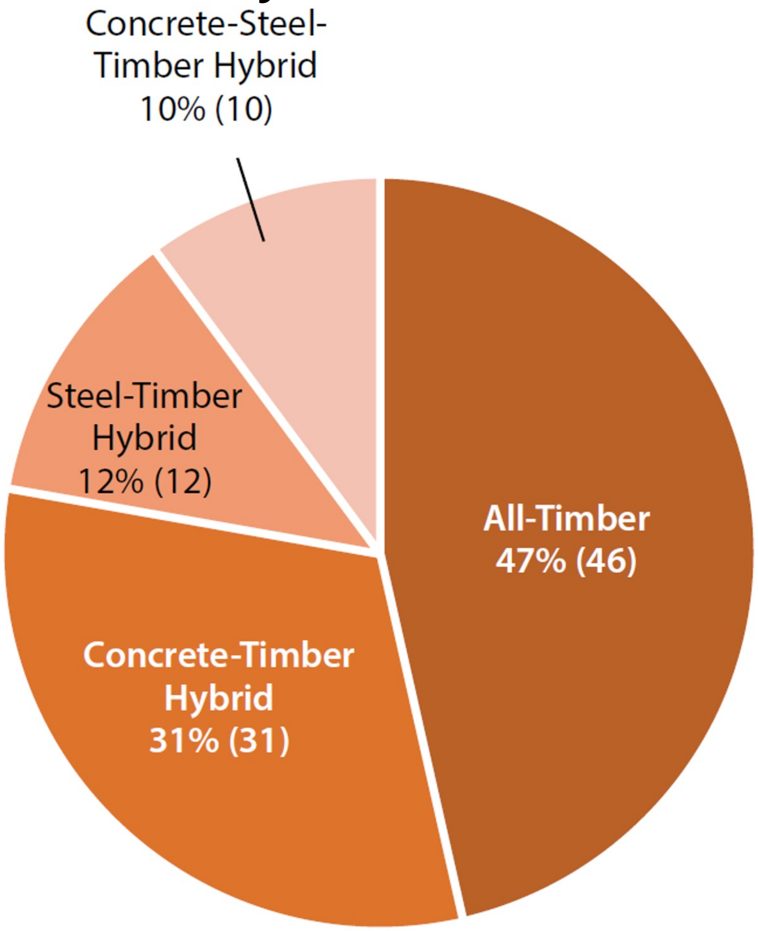


99 Projects Total

Tall Timber Global Audit:

Mass Timber Buildings, by Structure

The number of under construction and completed mass timber buildings, eight stories and higher, broken down by structural classification.

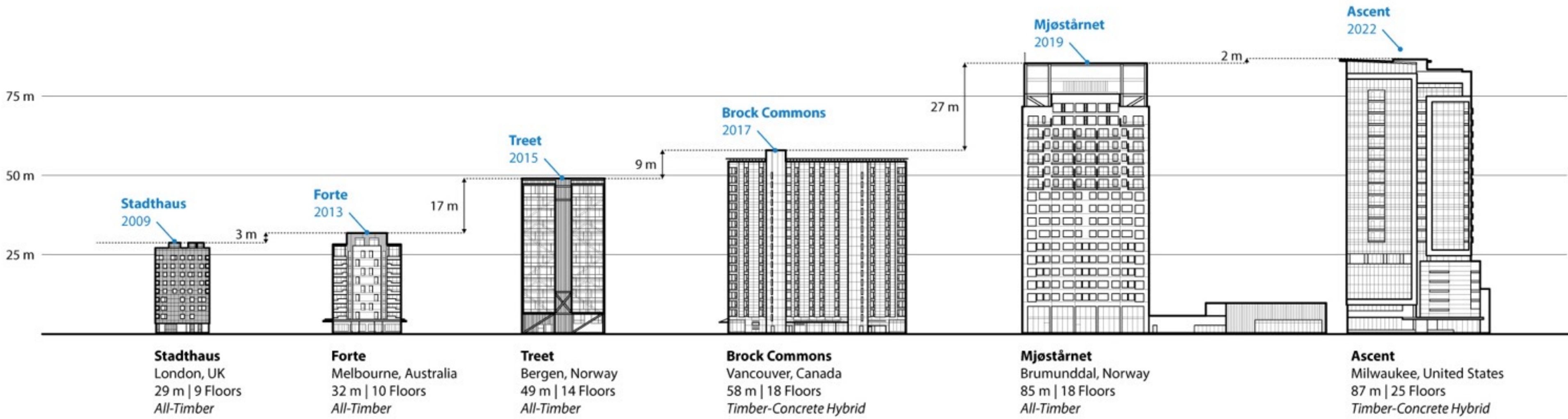


99 Projects Total

A Brief History of Tall Mass Timber:

Tallest Mass Timber Buildings

A graphical history of the tallest mass timber buildings in the world.*

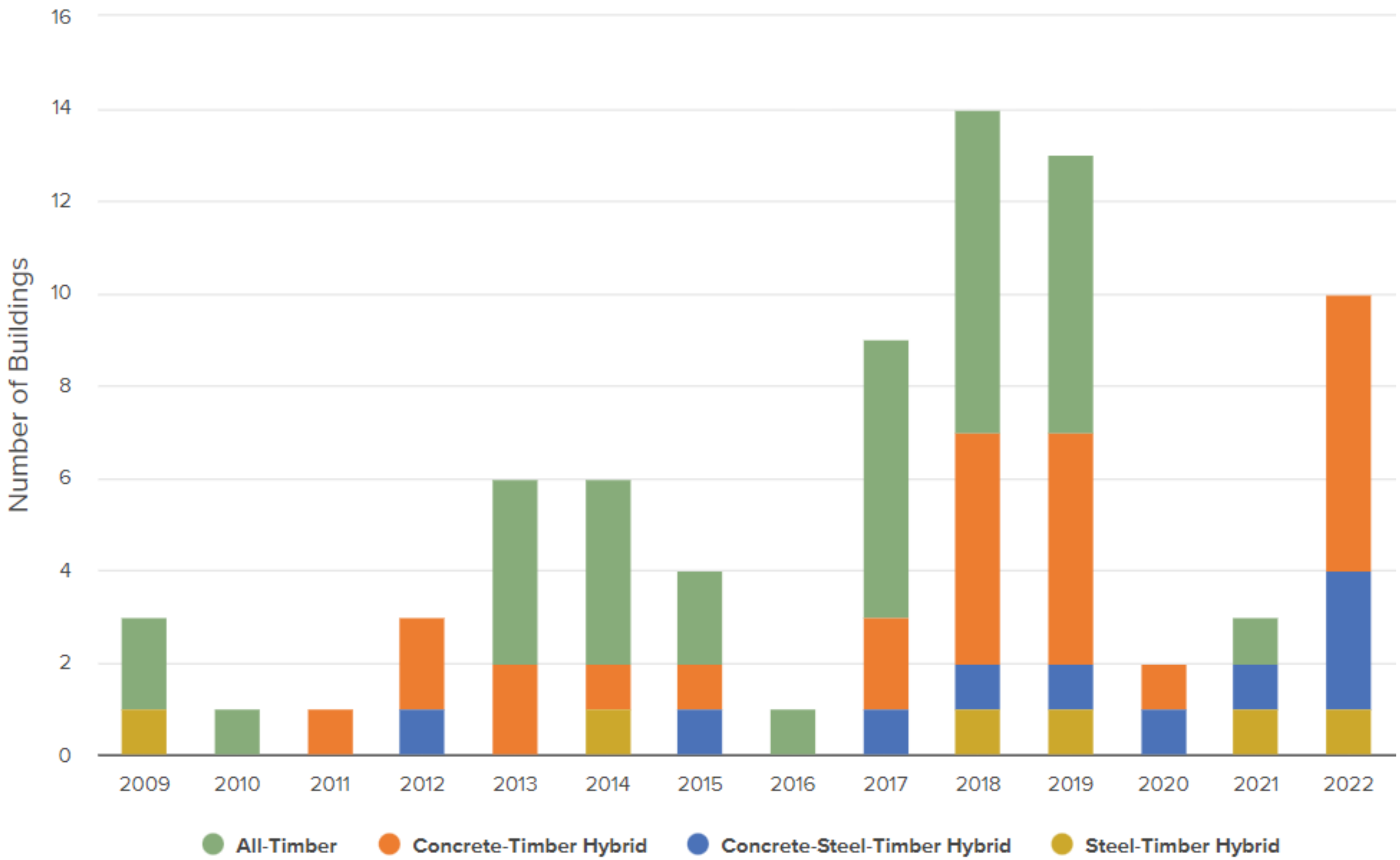


* This timeline includes new construction only. Vertical extensions (De Karel Doorman; 55 Southbank) are not included. If included, De Karel Doorman, Rotterdam, at 70.5 meters, would be the tallest Mass Timber Building between 2012 and 2019, being surpassed by Mjøstårnet (85.4 meters).

A Brief History of Tall Mass Timber:

Timeline of Completions

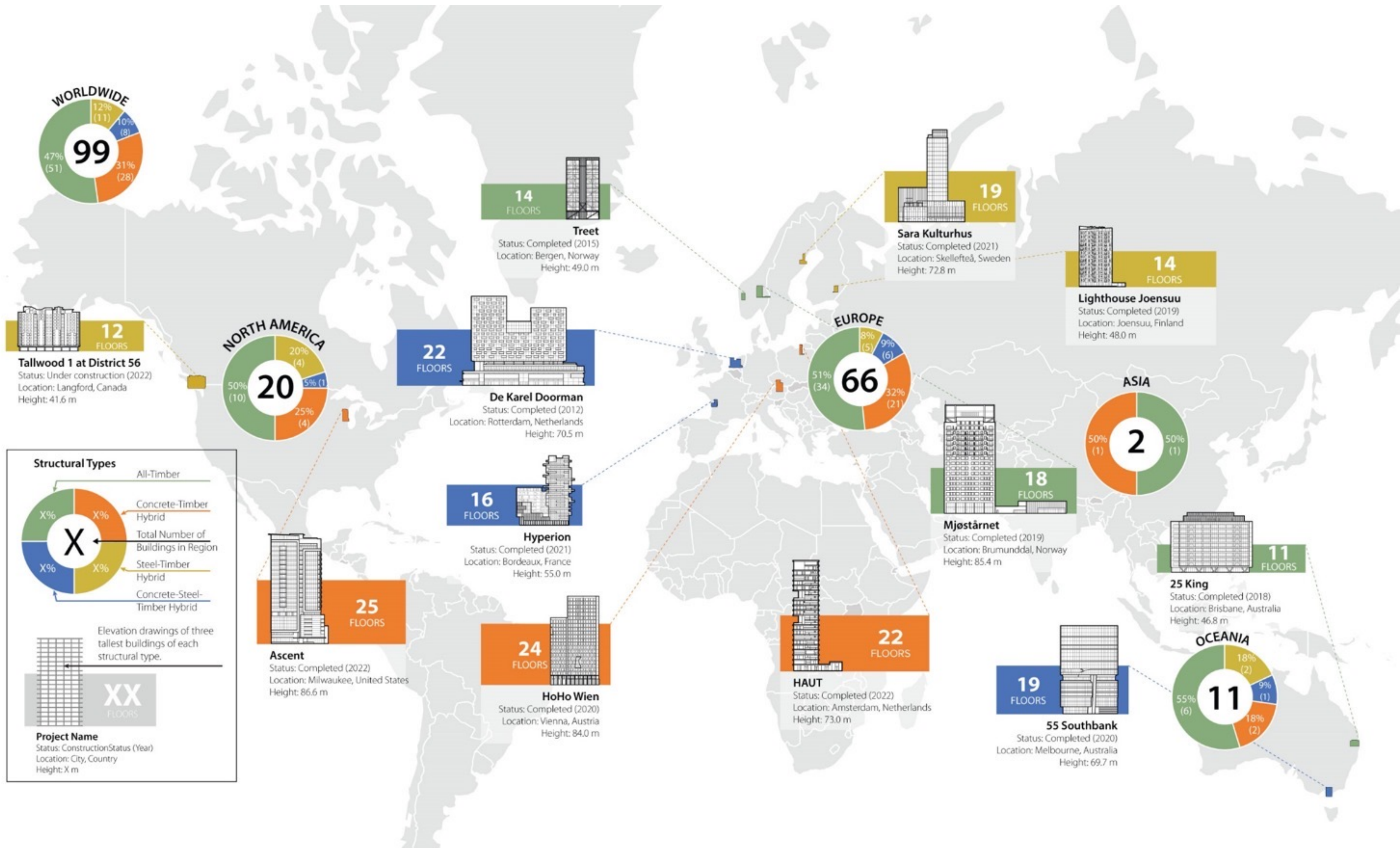
Mass timber buildings worldwide, 8 stories and higher, by completion year.



Tall Timber Global Audit:

Distribution of Structure Types

Global distribution of the tallest three buildings in each of the four structural categories.



Tall Timber Global Audit:

Tallest 10 Mass Timber Buildings

Rank	Building Name	City, Country	Height (m)	Floor Count	Structural System	Function	Status (as of Feb 2022)	Completion Year
1	Atlassian Central	Sydney, Australia	182.6	42	Concrete-Steel-Timber Hybrid	Mixed-Use	Under Construction	2027
2	Ascent	Milwaukee, USA	86.6	25	Concrete-Timber Hybrid	Residential	Completed	2022
3	Mjøstårnet	Brumunddal, Norway	85.4	18	All-Timber	Mixed-Use	Completed	2019
4	HoHo Wien	Vienna, Austria	84.0	24	Concrete-Timber Hybrid	Mixed-Use	Completed	2020
5	HAUT	Amsterdam, Netherlands	73.0	22	Concrete-Timber Hybrid	Residential	Completed	2022
6	Sara Kulturhus	Skellefteå, Sweden	72.8	19	Steel-Timber Hybrid	Mixed-Use	Completed	2021
7	De Karel Doorman	Rotterdam, Netherlands	70.5	22	Concrete-Steel-Timber Hybrid	Mixed-Use	Completed	2012
8	55 Southbank	Melbourne, Australia	69.7	19	Concrete-Steel-Timber Hybrid	Mixed-Use	Completed	2020
= 9	36-52 Wellington	Melbourne, Australia	65.0*	15	Concrete-Timber Hybrid	Office	Under Construction	2023
= 9	Roots Tower	Hamburg, Germany	65.0*	19	Concrete-Timber Hybrid	Residential	Under Construction	2023

* Heights are estimated, based on the floor count of the building. The estimate has been arrived at by analyzing thousands of other buildings of the same function on the CTBUH database that do have confirmed heights.

Featured Research:

Recent Mass Timber Research Projects

CTBUH Research Project:

Future Timber City

An Awareness and Educational Program for Future, Sustainable, Dense Cities

Project Start: August 2020
Project Completion: April 2023

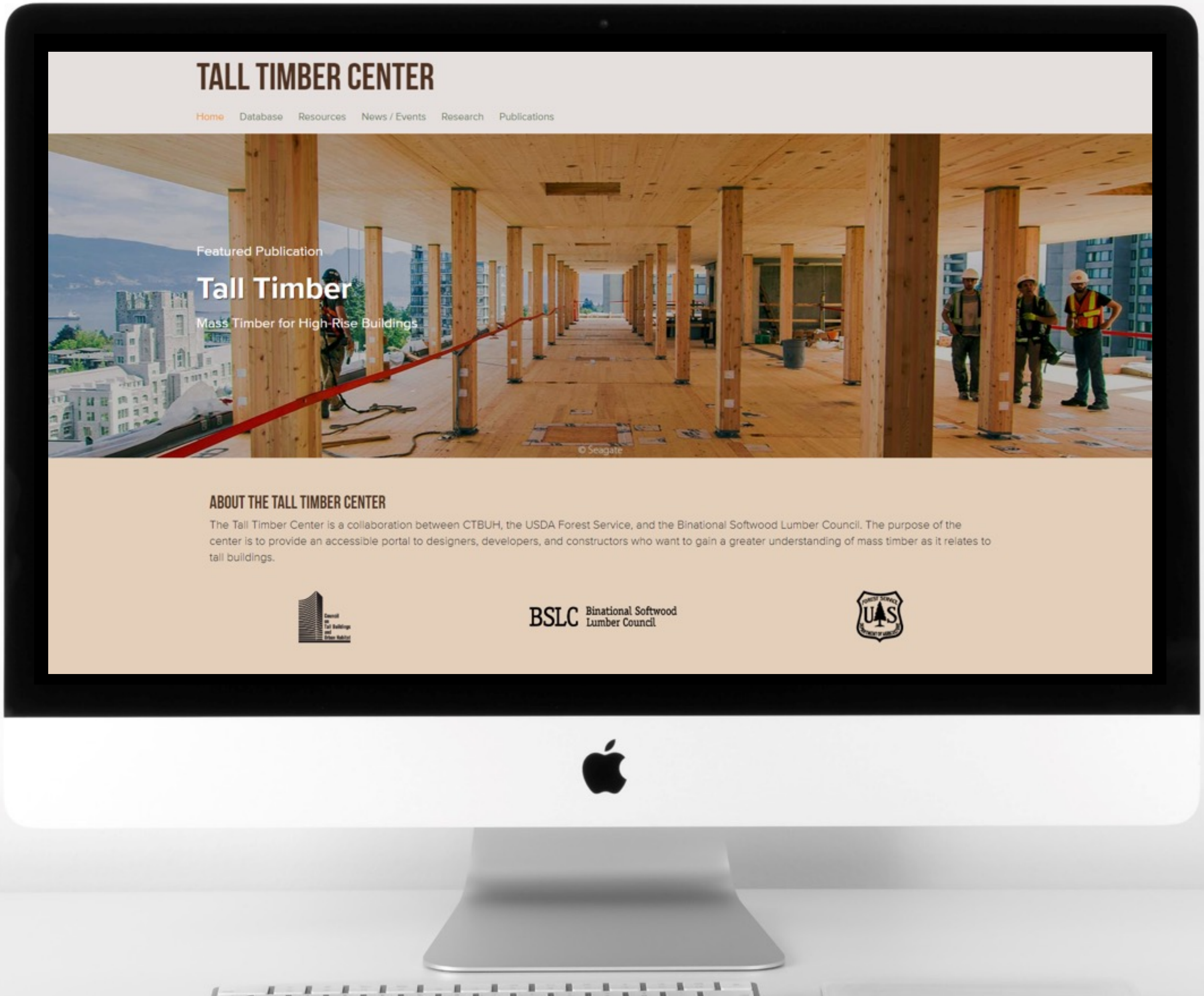
BSLC Binational Softwood Lumber Council

Overview | Steering Committee | Milestones | Partner

Given the market trajectory of building materials for tall buildings, it is likely that mass timber will be a critical building component for cities of the near future. It is incumbent upon government and the leaders of the timber industry to accelerate research in this field. We seek to provide a framework for better understanding the character and dimensions of a future mass timber city, and help to make it a reality. This program supports the dissemination of best-practice information on the design, technologies, construction, and planning of mass timber buildings and larger timber communities—in addition to a thorough historical review on the topic through the creation of a full-length technical publication. These activities will also produce a short film that visually articulates the design possibilities of a full-fledged timber city to capture the imagination of the general public to the sustainable benefits of mass timber, as well as the building industry.

CTBUH Research Project:

Tall Timber Center Website



CTBUH Research Project:

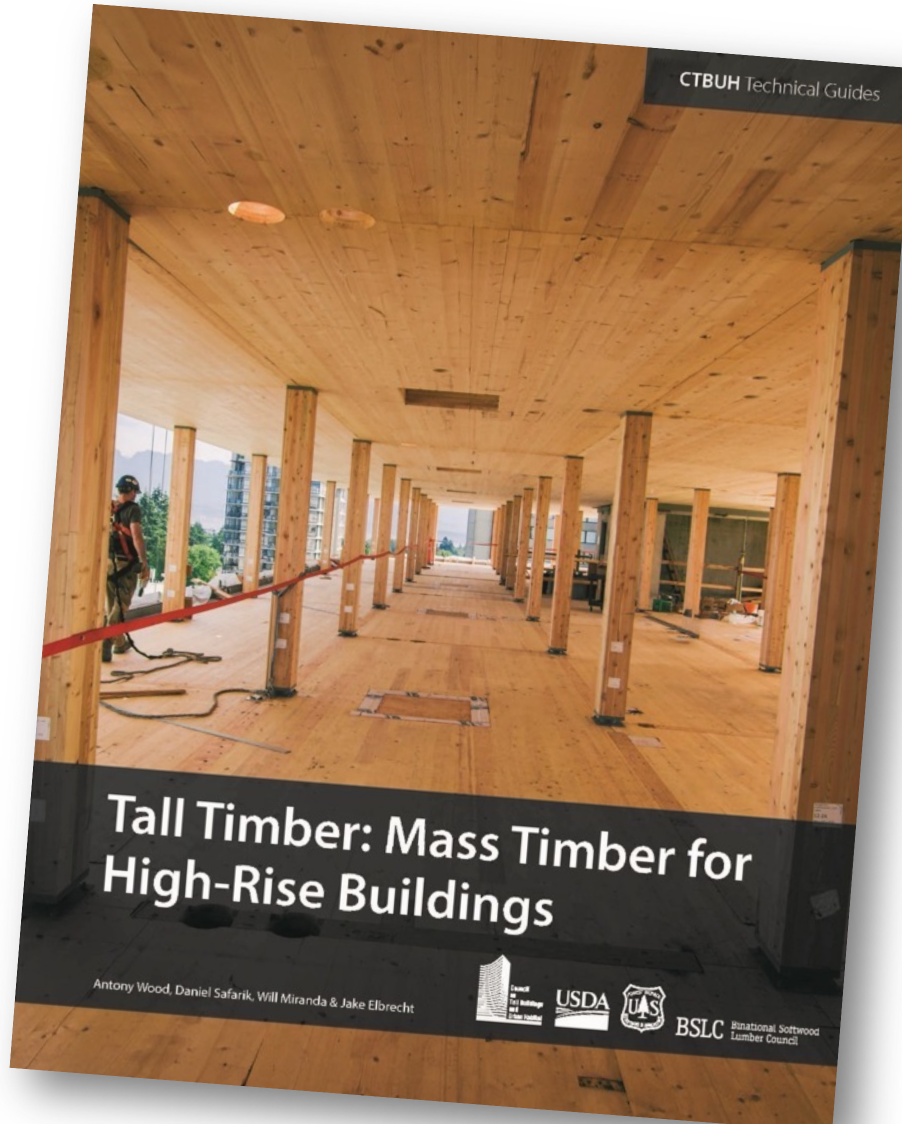
Technical Guide

Pages: **334**

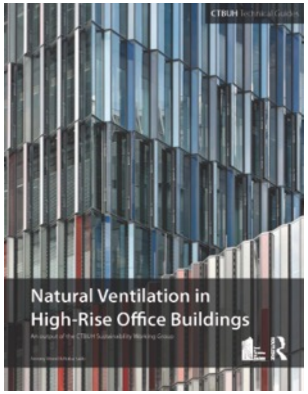
Case Studies: **25**

- In-Detail Examinations: **12**
- Projects "at-a-glance": **13**

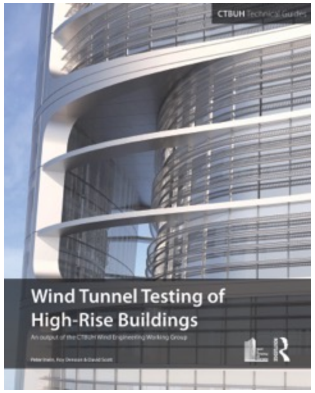
Key Topics: **13**



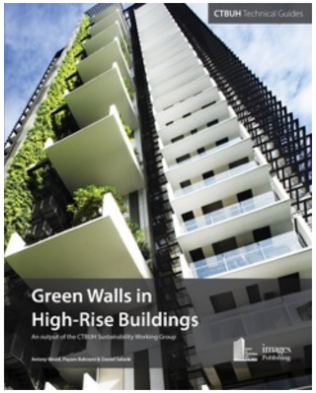
CTBUH Research Project:
Technical Guide Series



2012

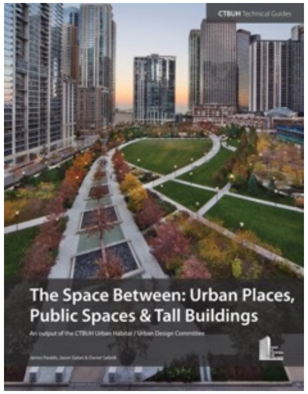


2013



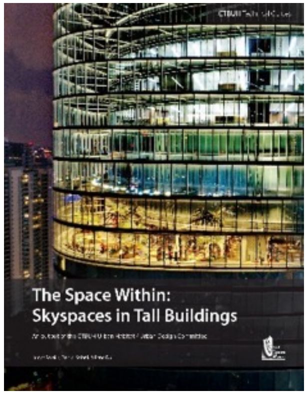
2014

2017



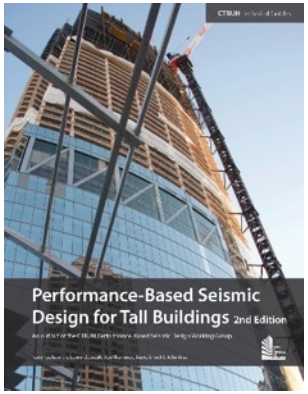
2017

2018

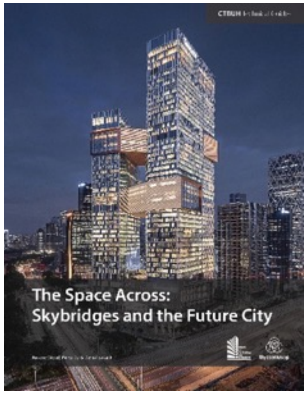


2018

2019



2019



2020

Tall Timber:

Mass Timber for High-Rise Buildings

Detailed Case Studies

2.1 Case Study

25 King

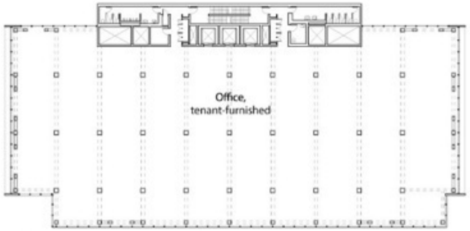
Brisbane, Australia

Background/Overview

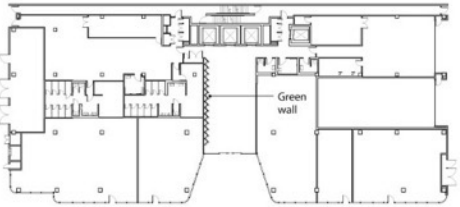
Located in the heart of Brisbane's Royal National Agricultural and Industrial Association of Queensland (RNA) Showgrounds, 25 King (see figures 2.1.1 and 2.1.2) is one of Australia's tallest and largest timber commercial buildings. The site anchors one end of King Street, a burgeoning precinct in Brisbane whose planners are working to prioritize sustainability and well-being through design. The building's expression—marked on the exterior by its ground-level timber colonnade and "verandah" south façade—nods to the Showgrounds' historic pavilions and traditional "Queenslander" buildings.

Owner/Developer Motivations

Although the building was initially conceived as having a concrete structure, the project site overlaps a road tunnel; the potential complications from this provided further incentive to use a lightweight structural material to achieve the desired height. When engineering firm Aurecon was secured as the anchor tenant, the company expressed a keen interest in a building that would communicate its commitment to sustainability, thus driving the decision to use timber. The developer and architect had confidence in this approach from prior success with



Levels 2–11: The typical office floor plan was designed to be flexible, allowing tenants to add partition walls and furniture where preferred.



Level 1 (Ground Floor): Common amenities are located on level 1 for the building's tenants.

1 m 5 m 10 m

◂ Figure 2.1.1. Overall view of 25 King, Brisbane. © Tom Roe

▴ Figure 2.1.2. Ground and typical floor plans. © Bates Smart, redrawn by CTBUH

Project Base Metrics

Status
- Completed: 2018

Building Function
- Office

Structural Classification
- All-Timber over Concrete

Structural Materials
- **Mass Timber:**
  Columns (GLT): levels 2 to 10
  Beams (GLT): levels 2 to 10
  Floors (CLT): levels 3 to 11
  Braces (GLT): levels 1 to 10
  Core (CLT): levels 2 to 11
- **Concrete:**
  Foundations
  Floors: levels -1 to 2
  Columns: levels -1 to 1
  Beams: levels -1 to 1
  Core: levels -1 to 1

Building Milestone Dates
- Construction start: May 2017
- Completion date: October 2018
- Construction period: 16 months

Height
- Height to architectural top: 46.8 meters
- Height to highest occupied floor: 34.4 meters
- Height to tip: 46.8 meters

Number of Floors
- Above grade: 11
- Below grade: 1

Building Floor Area
- Total gross floor area: 16,446 m^2
- Net internal area: 14,963 m^2
- Area of building footprint: 1,863 m^2
- Entire site/plot: 1,884 m^2
- Site coverage: 99%

Number of Elevators
- 4

Building Occupancy
- 1,500 persons

Building Density
- 11 m^2 GFA/person

Tall Timber: Mass Timber for High-Rise Buildings:

Analysis, Lessons Learned, and Future Objectives

Introduction

This chapter collects the findings of individual case studies in Chapter 2 and the key topics/considerations provided by discipline experts in Chapter 3, subjecting them to a broader analysis and commentary, organized in the same order in which the same key topics and factors of analysis appear in each case study. The objective is to reach a broad set of conclusions about state-of-the-art methods in mass timber design for high-rises, before moving to lessons learned and future objectives.

The case studies (see Table 4.0.1) were selected from a broader tall timber audit pool researched by CTBUH on several bases: height, preponderance of available information, unique or differentiated use of timber as a material, and high levels of stakeholder participation in the research. The case studies are representative of the broad spectrum of mass timber high-rises currently constructed, but the data produced was not exhaustive across all factors in each. This section summarizes the gathered statistics collected for each case study in the guide. Where a substantial quorum of figures could be obtained, comparisons are drawn. Even in cases where relatively little data could be obtained, the data is nevertheless displayed where it is known, as the authors believe this is part of creating an authoritative reference for a new way of building.

Building Characteristics

Function

In terms of function, of the 12 case studies in the Guide, two are office-only buildings, five are mixed-use, and five are either residential or hotel uses. Compared to the overall dataset of tall mass timber buildings, eight stories and higher (see *Chapter 1.3,* page 20), where 64 percent of the buildings are residential/or hotel functions, the case study residential/hotel projects represent a smaller proportion (42 percent).

Height/Area

The two extremes in this guide are represented by the newest and tallest (Ascent, Milwaukee) and the






Project Base Metrics	25 King, Brisbane, Australia	Ascent, Milwaukee, USA	Brock Commons, Vancouver, Canada	Dalston Works, London, UK	De Karel Doorman, Rotterdam, Netherlands	HoHo Wien, Vienna, Austria
Function	Office	Residential	Residential	Mixed-Use	Mixed-Use	Mixed-Use
Status	Completed: 2018	Completed: 2022	Completed: 2017	Completed: 2017	Completed: 2012	Completed: 2019
Structural classification	All-Timber over Concrete	Concrete-Timber Hybrid over Concrete	Concrete-Timber Hybrid over Concrete	All-Timber over Concrete	Concrete-Steel-Timber Hybrid over Concrete	Concrete-Timber Hybrid
Building Milestone Dates						
Construction start	May 2017	August 2020	November 2015	November 2014	Nov 2006, Mar 2011	October 2016
Completion date	October 2018	July 2022	May 2017	June 2017	October 2012	June 2019
Construction period	16 months	23 months	19 months	32 months	37 months	32 months
Height						
Height to architectural top	46.8 m	86.6 m	58 m	33.8 m	70.5 m	84 m
Height to highest occupied floor	34.4 m	79.4 m	54 m	29.2 m	66.1 m	79.2 m
Height to tip	46.8 m	86.6 m	58 m	33.8 m	71.2 m	84 m
Number of Floors						
Above grade	11	25	18	10	22	24
Below grade	1	0	0	1	1	2
Building Floor Area						
Total gross floor area	16,446 m^2	47,909 m^2	15,120 m^2	16,791 m^2	22,950 m^2	25,000 m^2
Net internal area	14,963 m^2	38,979 m^2	11,972 m^2	12,103 m^2	19,530 m^2	19,700 m^2
Area of building footprint	1,863 m^2	2,484 m^2	840 m^2	1,283 m^2	3,120 m^2	1,372 m^2
Entire site/plot	1,884 m^2	2,650 m^2	2,315 m^2	4,091 m^2	-	3,920 m^2
Site coverage	99%	94%	36%	31%	-	35%
Number of apartments	N/A	259	305	121	114	143
Number of elevators	4	3	2	10	4	6
Building occupancy	1,500 persons	2,623 persons	404 persons	2,058 persons	-	818 persons
Building density	11 m^2 GFA/person	18.3 m^2 GFA/person	37.4 m^2 GFA/person	8.1 m^2 GFA/person	-	31 m^2 GFA/person






Project Base Metrics	LCT One, Dornbirn, Austria	Mjøstårnet, Brumunddal, Norway	Origine, Québec, Canada	Sara Kulturhus, Skellefteå, Sweden	Stadthaus, London, UK	Treet, Bergen, Norway	Average
Function	Office	Mixed-Use	Residential	Mixed-Use	Residential	Residential	
Status	Completed: 2012	Completed: 2019	Completed: 2017	Completed: 2021	Completed: 2009	Completed: 2015	
Structural classification	Concrete-Timber Hybrid	All-Timber	All-Timber over Concrete	All-Timber over Steel-Timber Hybrid	All-Timber over Concrete	All-Timber over Concrete	
Building Milestone Dates							
Construction start	September 2011	April 2017	June 2016	November 2018	February 2008	April 2014	
Completion date	September 2012	March 2019	October 2017	October 2021	January 2009	December 2015	
Construction period	12 months	23 months	17 months	36 months	11 months	21 months	**22.5 months**
Height							
Height to architectural top	27 m	85.4 m	40.9 m	72.8 m	29 m	49 m	**57.0 m**
Height to highest occupied floor	22 m	68.2 m	40 m	66.8 m	23.2 m	44.3 m	**50.6 m**
Height to tip	27 m	88.8 m	40.9 m	72.8 m	29 m	49 m	**57.3 m**
Number of Floors							
Above grade	7	18	13	20	9	14	**16**
Below grade	1	1	1	1	0	1	**1**
Building Floor Area							
Total gross floor area	2,319 m^2	11,480 m^2	11,547 m^2	28,000 m^2	2,750 m^2	8,080 m^2	**17,366 m^2**
Net internal area	1,774 m^2	11,300 m^2	-	27,867 m^2	1,861 m^2	5,830 m^2	**15,080 m^2**
Area of building footprint	301 m^2	3,752 m^2	1,686 m^2	5,957 m^2	280 m^2	490 m^2	**1,952 m^2**
Entire site/plot	-	15,680 m^2	2,025 m^2	7,100 m^2	860 m^2	2,600 m^2	**4,313 m^2**
Site coverage	-	24%	83%	84% m^2	33%	19%	**54%**
Number of apartments	N/A	105	93	208	29	62	**144**
Number of elevators	1	3	2	8	2	1	**4**
Building occupancy	147 persons	913 persons	282 persons	-	118 persons	-	**988 persons**
Building density	15.7 m^2 GFA/person	10.7 m^2 GFA/person	40.9 m^2 GFA/person	-	23.3 m^2 GFA/person	-	21.8 m^2 GFA/person

▲ Table 4.0.1. The project base metrics data from each case study provides a comparison of height, area, and occupancy.

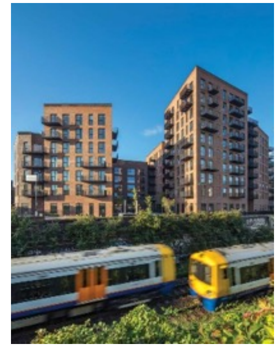
Tall Timber: Mass Timber for High-Rise Buildings:

Detailed Case Studies

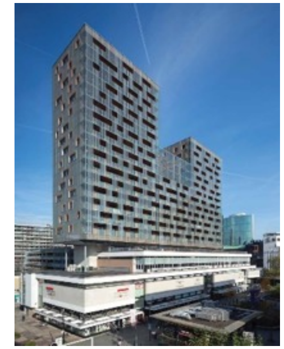
25 King
2018
Brisbane, Australia
46.8 m / 11 Fl

Ascent
2022
Milwaukee, USA
86.6 m / 25 Fl

Brock Commons
2017
Vancouver, Canada
57.9 m / 18 Fl



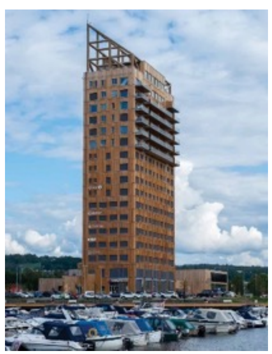
Dalston Works
2017
London, UK
33.8 m / 10 Fl



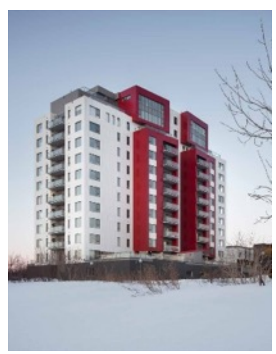
De Karel Doorman
2012
Rotterdam, Neth.
70.5 m / 22 Fl

HoHo Wien
2020
Vienna, Austria
84.0 m / 24 Fl

LCT ONE
2012
Dornbirn, Australia
27 m / 8 Fl



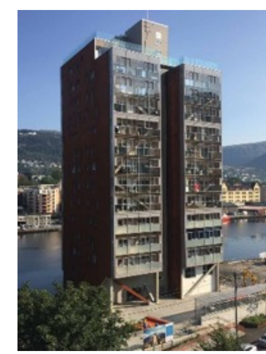
Mjostarnet
2019
Brumunddal, Nor.
85.3 m / 18 Fl



Origine
2017
Quebec, Canada
48.0 m / 13 Fl

Sara Kulturhus
2021
Skellefteå, Sweden
72.8 m / 19 Fl

Stadthaus
2009
London, UK
29 m / 9 Fl



Treet
2018
Bergen, Norway
49 m / 14 Fl

Tall Timber: Mass Timber for High-Rise Buildings:

Case Study Dimensions of Analysis

1. Owner/Developer Motivations
2. Cost Considerations
3. Carbon and Sustainability Overview
4. Use/Exposure of Mass Timber
5. Structural Systems
6. Code Considerations
7. Material Testing
8. Fire Safety Engineering
9. Acoustics
10. MEP Systems
11. Building Envelope
12. Construction Process
    a. Sourcing and Supply Chain
    b. Prefabrication
    c. Site Delivery
    d. On-Site Construction
    e. Tolerances and Accuracy Testing
    f. Fire Protection During Construction
    g. Moisture Management During Construction
13. Post-Occupancy Evaluation

Case Study Base Metrics

	25 King Brisbane, Australia 	**Ascent** Milwaukee, USA 	**Brock Commons** Vancouver, Canada 	**Dalston Works** London, UK 	**De Karel Doorman** Rotterdam, Netherlands 	**HoHo Wien** Vienna, Austria 
Project Base Metrics						
Function	Office	Residential	Residential	Mixed-Use	Mixed-Use	Mixed-Use
Status	Completed: 2018	Completed: 2022	Completed: 2017	Completed: 2017	Completed: 2012	Completed: 2019
Structural classification	All-Timber over Concrete	Concrete-Timber Hybrid over Concrete	Concrete-Timber Hybrid over Concrete	All-Timber over Concrete	Concrete-Steel-Timber Hybrid over Concrete	Concrete-Timber Hybrid
Building Milestone Dates						
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Completion date	October 2018	July 2022	May 2017	June 2017	October 2012	June 2019
Construction period	16 months	23 months	19 months	32 months	37 months	32 months
Height						
Height to architectural top	46.8 m	86.6 m	58 m	33.8 m	70.5 m	84 m
Height to highest occupied floor	34.4 m	79.4 m	54 m	29.2 m	66.1 m	79.2 m
Height to tip	46.8 m	86.6 m	58 m	33.8 m	71.2 m	84 m
Number of Floors						
Above grade	11	25	18	10	22	24
Below grade	1	0	0	1	1	2
Building Floor Area						
Total gross floor area	16,446 m^2	47,909 m^2	15,120 m^2	16,791 m^2	22,950 m^2	25,000 m^2
Net internal area	14,963 m^2	38,979 m^2	11,972 m^2	12,103 m^2	19,530 m^2	19,700 m^2
Area of building footprint	1,863 m^2	2,484 m^2	840 m^2	1,283 m^2	3,120 m^2	1,372 m^2
Entire site/plot	1,884 m^2	2,650 m^2	2,315 m^2	4,091 m^2	-	3,920 m^2
Site coverage	99%	94%	36%	31%	-	35%
Number of apartments	N/A	259	305	121	114	143
Number of elevators	4	3	2	10	4	6
Building occupancy	1,500 persons	2,623 persons	404 persons	2,058 persons	-	818 persons
Building density	11 m^2 GFA/person	18.3 m^2 GFA/person	37.4 m^2 GFA/person	8.1 m^2 GFA/person	-	31 m^2 GFA/person

Tall Timber: Mass Timber for High-Rise Buildings:

Case Study Base Metrics (Cont'd)






	LCT One Dornbirn, Austria	**Mjøstårnet** Brumunddal, Norway	**Origine** Québec, Canada	**Sara Kulturhus** Skellefteå, Sweden	**Stadthaus** London, UK	**Treet** Bergen, Norway	**Average**
Project Base Metrics							
Function	Office	Mixed-Use	Residential	Mixed-Use	Residential	Residential	
Status	Completed: 2012	Completed: 2019	Completed: 2017	Completed: 2021	Completed: 2009	Completed: 2015	
Structural classification	Concrete-Timber Hybrid	All-Timber	All-Timber over Concrete	All-Timber over Steel-Timber Hybrid	All-Timber over Concrete	All-Timber over Concrete	
Building Milestone Dates							
Construction start	September 2011	April 2017	June 2016	November 2018	February 2008	April 2014	
Completion date	September 2012	March 2019	October 2017	October 2021	January 2009	December 2015	
Construction period	12 months	23 months	17 months	36 months	11 months	21 months	22.5 months
Height							
Height to architectural top	27 m	85.4 m	40.9 m	72.8 m	29 m	49 m	**57.0 m**
Height to highest occupied floor	22 m	68.2 m	40 m	66.8 m	23.2 m	44.3 m	**50.6 m**
Height to tip	27 m	88.8 m	40.9 m	72.8 m	29 m	49 m	**57.3 m**
Number of Floors							
Above grade	7	18	13	20	9	14	**16**
Below grade	1	1	1	1	0	1	**1**
Building Floor Area							
Total gross floor area	2,319 m^2	11,480 m^2	11,547 m^2	28,000 m^2	2,750 m^2	8,080 m^2	**17,366 m^2**
Net internal area	1,774 m^2	11,300 m^2	-	27,867 m^2	1,861 m^2	5,830 m^2	**15,080 m^2**
Area of building footprint	301 m^2	3,752 m^2	1,686 m^2	5,957 m^2	280 m^2	490 m^2	**1,952 m^2**
Entire site/plot	-	15,680 m^2	2,025 m^2	7,100 m^2	860 m^2	2,600 m^2	**4,313 m^2**
Site coverage	-	24%	83%	84% m^2	33%	19%	**54%**
Number of apartments	N/A	105	93	208	29	62	**144**
Number of elevators	1	3	2	8	2	1	**4**
Building occupancy	147 persons	913 persons	282 persons	-	118 persons	-	**988** persons
Building density	15.7 m^2 GFA/person	10.7 m^2 GFA/person	40.9 m^2 GFA/person	-	23.3 m^2 GFA/person	-	21.8 m^2 GFA/person

Tall Timber: Mass Timber for High-Rise Buildings:

Case Study Mass Timber Information









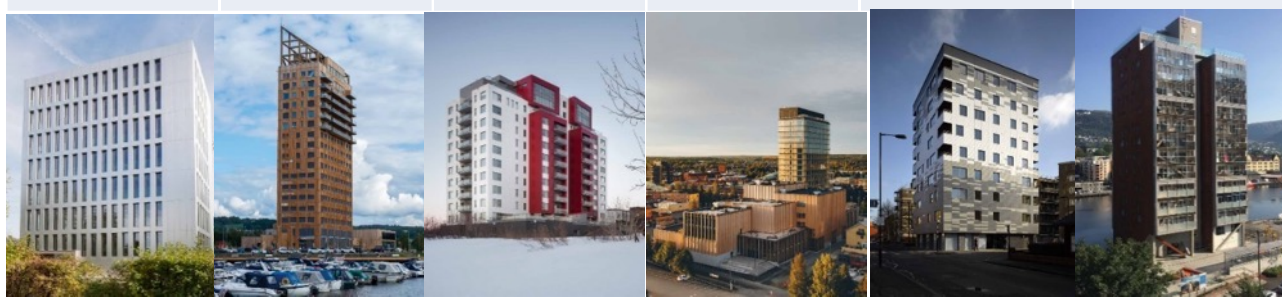



Mass Timber Information	**25 King** Brisbane, Australia	**Ascent** Milwaukee, USA	**Brock Commons** Vancouver, Canada	**Dalston Works** London, UK	**De Karel Doorman** Rotterdam, Netherlands	**HoHo Wien** Vienna, Austria	**LCT One** Dornbirn, Austria	**Mjøstårnet** Brumunddal, Norway	**Origine** Québec, Canada	**Sara Kulturhus** Skellefteå, Sweden	**Stadthaus** London, UK	**Treet** Bergen, Norway
Mass timber												
Floors (CLT)	Levels 3 to 11	Levels 7 to 25	Levels 3 to 18	Levels 3 to 10	-	Levels 2 to 24	-	-	Levels 3 to 13	Levels 2 to 4	Levels 3 to 9	-
Framed floors (LVL)	-	-	-	-	Levels 7 to 22	-	-	Levels 2 to 11	-	-	-	-
Columns (GLT)	Levels 2 to 10	Levels 7 to 25	Levels 2 to 18	-	-	Levels 1 to 24	Levels 1 to 7	Levels 1 to 17	Levels 2 to 13 -	Levels 1 to 4 and levels 19 to 20	-	Levels 1 to 14
Columns (PSL)	-	-	Levels 2 to 5	-	-	-	-	-	-	-	-	-
Beams (GLT)	Levels 2 to 10	Levels 7 to 25	-	-	-	-	Levels 1 to 7	Levels 1 to 17	Levels 2 to 13	Levels 1 to 4	-	Levels 1 to 14
Core (CLT)	Levels 2 to 11	-	-	Levels 2 to 10	-	-	-	Levels 1 to 18	-	Levels 1 to 20	Levels 2 to 9	Levels 1 to 14
Modules (GLT/ CLT)	-	-	-	-	-	-	-	-	-	Levels 6 to 18	-	-
Braces (GLT)	Levels 1 to 10	-	-	-	-	-	-	Levels 1 to 18	-	-	-	Levels 1 to 14
Walls (CLT)	-	-	-	Levels 2 to 10	-	-	-	-	Levels 2 to 13	-	Levels 2 to 9	-
Roofs (CLT)	-	-	-	Levels 6 to 10	-	-	-	-	-	-	-	-
Façade	-	-	-	-	-	Levels 1 to 24	-	-	-	-	-	-
Pergola (GLT)	-	-	-	-	-	-	-	Level 18	-	-	-	-
Balconies (CLT)	-	-	-	-	-	-	-	-	-	-	-	Levels 2 to 14
Concrete												
Foundations	✓	✓	✓	✓	Foundations	✓	✓	✓	Raft foundation	✓	✓	✓
Floors	Levels -1 to 2	Levels 1 to 6	Level 1	Levels -1 to 1	Levels -1 to 6	Levels -2 to 24	Levels -1 to 1	Levels -1 and 12 to 18	Levels -1 to 1	Levels -1 to 1, 5, 19, and 20	Levels 1 to 2	Levels -1 to 1
Columns	Levels -1 to 1	Levels 1 to 6	Level 1	Level -1	Levels -1 to 6	Levels -2 to -1	-	-	Levels -1 to 1	Level -1	-	Level -1
Beams:	Levels -1 to 1	Levels 1 to 6	-	-	-	Levels 1 to 24	Perimeter edge beams: Levels 1 to 7	-	-	-	-	-
Cores:	Levels -1 to 1	Levels 1 to 25	Levels 1 to 18	Level 1	Levels -1 to 22	Levels 1-24	Levels 1 to 7	-	Levels -1 to 1	-	Level 1	-
Transfer slab	-	-	Level 2	Level 2	-	-	-	-	Level 2	-	-	-
Structural floor topping	-	-	-	-	-	-	Levels 2 to 7	-	-	-	-	-
Walls	-	-	-	-	-	-	-	-	-	-	Level 1	-
Steel												
Columns	Level 11	-	Perimeter Angles	-	Levels 7 to 22	-	-	-	-	Levels 1, 19 to 20	-	-
Beams	-	-	-	-	Levels 7 to 22	-	-	-	Beams connecting the concrete transfer slab and CLT walls: Level 2	-	-	-
Roof framing	Level 11	-	Yes	-	-	-	-	-	-	-	-	-
Box Truss	-	-	-	-	-	-	-	-	-	Level 5	-	-
Total mass timber volume	6,206 m³	7,371 m³	2,283 m³	3,958 m³	472 m³	4,633 m³	264 m³	2,654 m³	2,923 m³	12,022 m³	901 m³	925 m³
Total mass timber volume/gross floor area	0.38 m³/m²	0.15 m³/m²	0.15 m³/m²	0.24 m³/m²	0.02 m³/m²	0.19 m³/m²	0.11 m³/m²	0.23 m³/m²	0.25 m³/m²	0.43 m³/m²	0.33 m³/m²	0.11 m³/m²
Total mass timber weight	2,978,880 kg	3,511,331 kg	1,075,222 kg	1,900,000 kg	240,720 kg	2,177,214 kg	136,034 kg	1,177,000 kg	1,199,513 kg	5,169,460 kg	432,480 kg	414,000 kg
Average mass weight / GFA	181 kg/m²	73 kg/m²	71 kg/m²	113 kg/m²	10 kg/m²	87 kg/m²	59 kg/m²	103 kg/m²	104 kg/m²	185 kg/m²	157 kg/m²	51 kg/m²

Case Study Mass Timber Information:

Timber Quantities

	25 King	Ascent	Brock	Dalston	De Karel	HoHo
Volume (m^3)	6,206	7,371	2,283	3,958	472	4,633
Vol/.GFA (m^3 / m^2)	0.38	0.15	0.15	0.24	0.02	0.11
Weight (kg)	2,978,880	3,511,331	1,075,222	1,900,000	240,720	2,177,214
Ave. kg / m^2	181	73	71	113	10	87



	LCT One	Mjost.	Origine	Sara K.	Stadthaus	Treet
Volume (m^3)	264	2,654	2,923	12,022	901	925
Vol/.GFA (m^3 / m^2)	0.11	0.23	0.25	0.43	0.33	0.11
Weight (kg)	136,034	1,177,000	1,199,513	5,169,460	432,480	2,177,214
Ave. kg / m^2	59	103	104	185	157	87

Tall Timber: Mass Timber for High-Rise Buildings:

Cost Considerations

Example: Comparison of construction costs of Brock Commons Tallwood House, a mass timber student-housing high-rise, and Ponderosa Cedar House, a conventional concrete building of the same size, in Vancouver.

Construction Cost Comparison

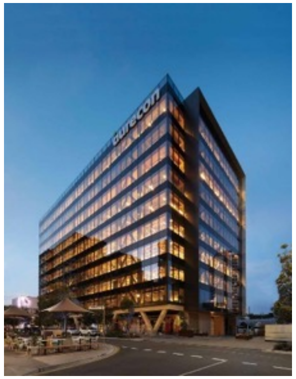
	Brock Commons, July 2017		Ponderosa Cedar House, July 2017		% Difference
	CA$	US$*	CA$	US$*	%
Procurement and general requirements	3,661,566	2,819,398	3,374,663	2,598,491	109%
Concrete	3,694,268	2,844,586	6,628,694	5,104,094	56%
Metal	910,565	701,135	432,487	333,015	211%
Wood and plastics	3,731,316	2,873,113	746,563	574,854	500%
Thermal and moisture protection openings	5,253,529	4,045,217	5,131,827	3,951,507	102%
Openings	2,053,890	1,581,495	2,076,157	1,598,641	99%
Finishes	4,979,374	3,834,118	3,860,899	2,972,892	129%
Furnishings	2,130,925	1,640,812	1,475,266	1,135,955	144%
Mechanical	6,304,947	4,854,809	5,996,830	4,617,559	105%
Electrical	3,510,015	2,702,712	3,135,210	2,414,112	112%
Misc. Costs	4,277,944	3,294,017	4,821,870	3,712,840	89%
Total Construction Cost	**40,508,329**	**31,191,413**	**37,110,466**	**29,013,959**	**108%**

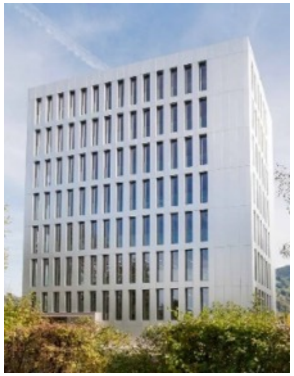
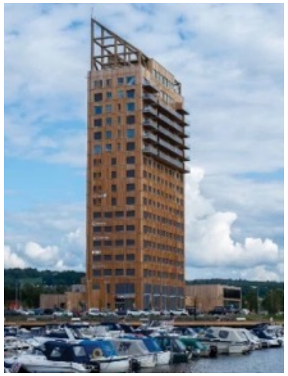
*Costs are in July 2017 CA$, converted to July 2017 US$ at exchange rate CA$1 = USD$0.77

8% construction cost premium for choosing timber

Tall Timber: Mass Timber for High-Rise Buildings:

Construction Costs Comparison




Construction Costs					
	25 King **Brisbane, Australia**	**Brock Commons** **Vancouver, Canada**	**LCT One** **Dornbirn, Austria**	**Mjøstårnet** **Brumunddal, Norway**	**Origine** **Québec, Canada**
Total Construction Cost (US$)	46,251,405 (Oct. 2018 US$)	31,191,413 (July 2017 US$)	5,913,892 (Sept. 2012 US$)	45,051,868 (March 2019 US$)	16,113,963 (Oct. 2017 US$)
Inflation Value (US$)	1.17	1.21	1.28	1.17	1.20
Total Construction Cost (December 2022 US$)	54,114,144	37,741,610	7,569,782	52,710,686	19,336,756
Total Construction Cost per Unit Area (2022 US$/$m^2$)	3,290	2,496	3,264	4,591.52	1,675

Carbon Considerations

Example: Total embodied carbon estimates for Brock Commons Tallwood House, Vancouver, based on life cycle analysis modules.

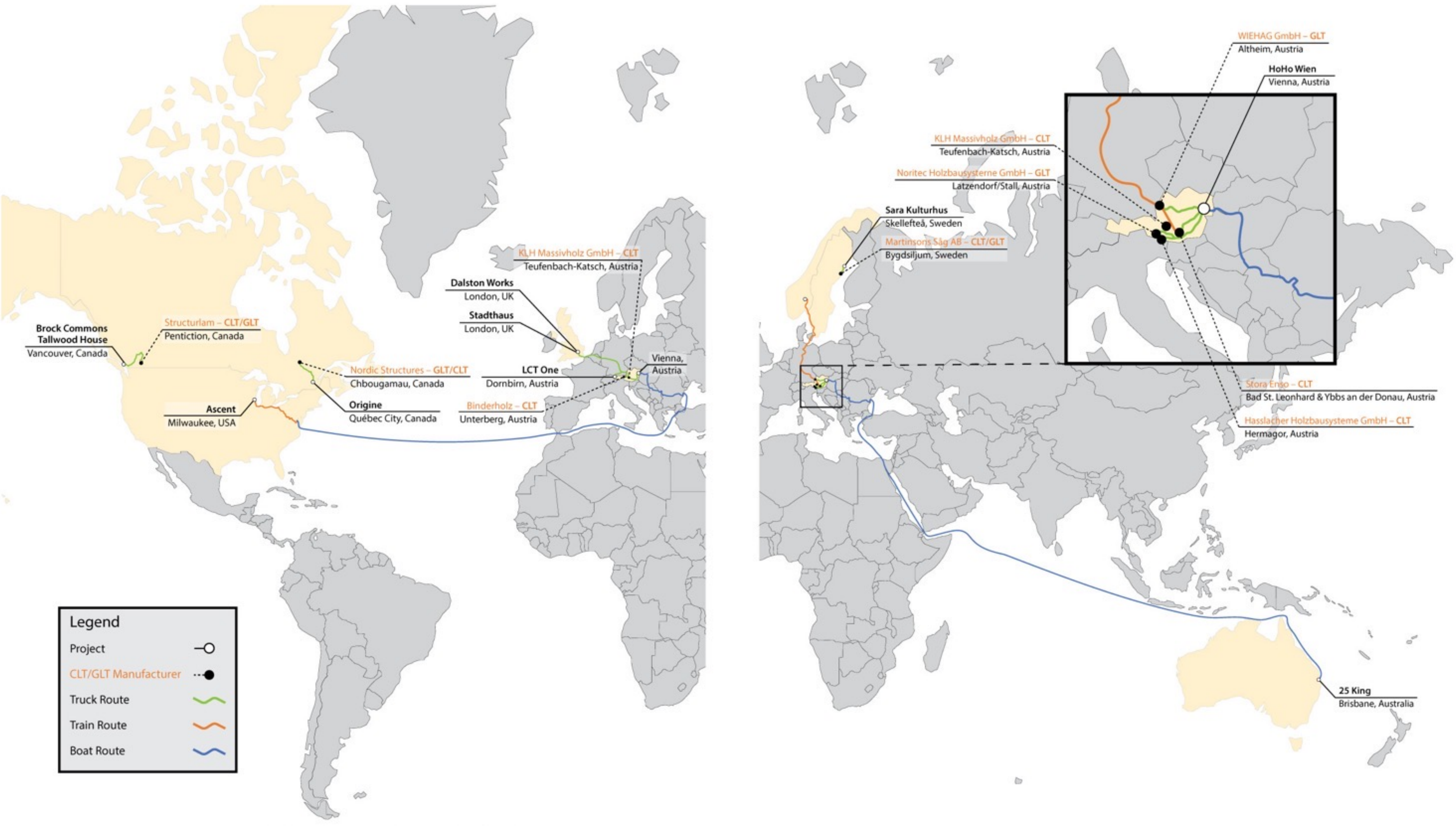
Total Embodied Carbon (kg CO_2 eq), Based on EBD (Environmental Building Declaration) Modules						
Phases	Modules	Brock Commons		Ponderosa Cedar House		% Difference
		Estimated GHG emissions (kg CO_2 eq)	Normalized to floor area (kg CO_2 eq/m²)	Estimated GHG emissions (kg CO_2 eq)	Normalized to floor area (kg CO_2 eq)	Difference normalized to floor area
Manufacturing and Construction	A1 Raw material supply A2 Transport A3 Manufacturing	2,690,000	178.0	3,440,000	268.0	66%
	A4 Transport	159,000	10.5	124,000	9.7	109%
	A5 Construction installation process	183,000	12.1	185,000	14.4	84%
Use	B2 Maintenance	30,600	2.0	36,100	2.8	72%
	B3 Repair	480,000	31.7	500,000	38.9	82%
	B4 Replacement	1,020,000	67.5	872,000	67.9	99%
End of Life	C1 Deconstruction	109,000	7.2	120,000	9.3	77%
	C2 Transport	51,400	3.4	51,800	4.0	84%
	C3 Waste processing	17,100	1.1	15,500	1.2	94%
	C4 Disposal	18,700	1.2	26,500	2.1	60%
Results	Total estimated GHG emissions	4,760,000	315.0	5,370,000	418.0	75%

75% reduction in GHG emissions compared to concrete alternative

Tall Timber: Mass Timber for High-Rise Buildings:

Transportation Paths

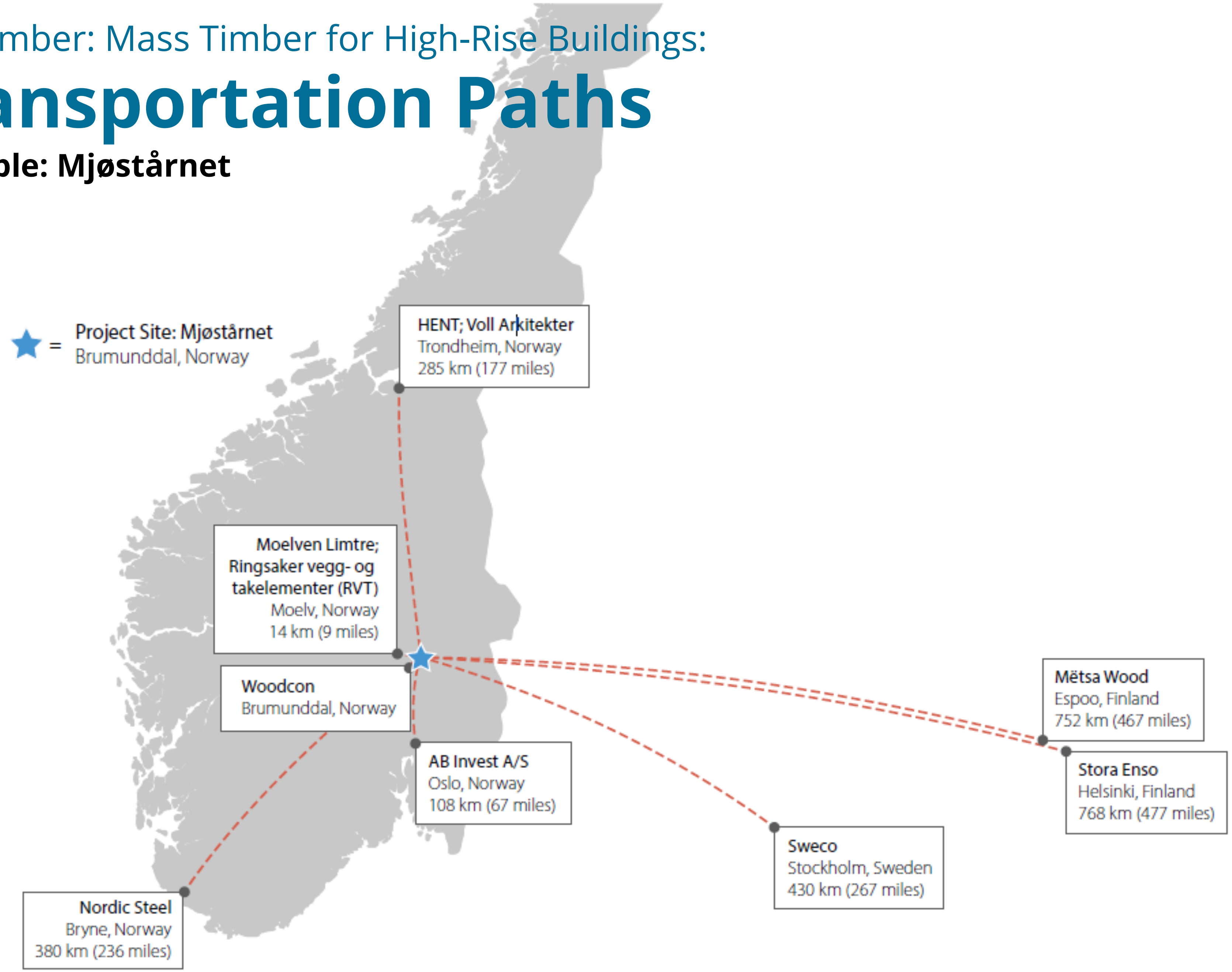
Approximate routes taken by the raw materials and prefabricated components of the 12 case studies in the guide.



Tall Timber: Mass Timber for High-Rise Buildings:

Transportation Paths

Example: Mjøstårnet



Tall Timber: Mass Timber for High-Rise Buildings:

Carbon Emissions and Storage

Carbon Emissions and Storage							
	25 King Brisbane, Australia	**Brock Commons Vancouver, Canada**	**Dalston Works London, United Kingdom**	**LCT One Dornbirn, Austria**	**Origine, Québec, Canada**	**Sara Kulturhus Skellefteå, Sweden**	**Stadthaus London, United Kingdom**
Total estimated embodied GHG emissions (kg CO_2 eq)	8,105,839	4,760,000	-	583,650	1,787,942	4,827,903	-
Total estimated embodied GHG emissions per unit area (kg CO_2 eq/m^2)	493	315	-	329	155	172	-
Carbon Storage							
Total carbon sequestered within structural timber	4,399,056	1,753,000	3,560,000	245,441	2,166,995	8,017,188	718,667
Net carbon emissions of the structure (total emissions minus sequestration)	3,706,783	3,007,000	-925,000	338,209	-379,053	-3,189,285	-
Total carbon emissions avoided by using timber over conventional materials	8,020,786	610,000	-	250,100	907,639	4,592,926	682,620

The Elephant in the Room


SIXTH FORM

Fire Restrictions

Ministry of Housing,
Communities &
Local Government

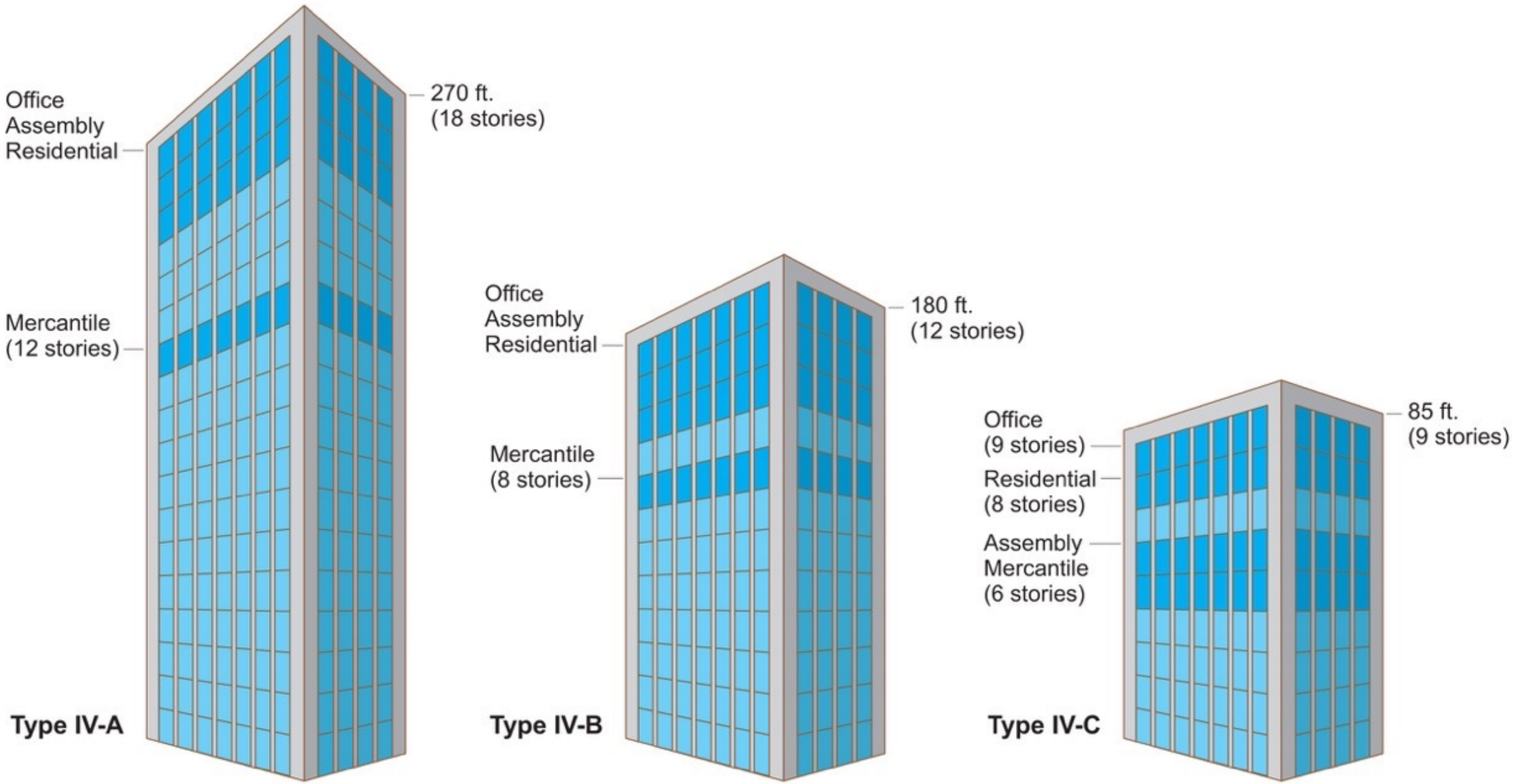
Ministry of Housing, Communities and Local Government

Final Impact Assessment: Ban on combustible materials in external wall systems. Building (Amendment) Regulations 2018 SI 2018/1230

vii. Timber building

a. The policy prohibits the use of timber materials in the external wall of buildings within the scope. Currently the number of projects above 18m in height where load bearing structural timber elements are used remains relatively small. The effect of the ban on the use of engineered timber remains limited in the short term. There is however a growing number of buildings above 18m in height using engineered timber as part of their structure. Engineered timber offers an alternative to traditional methods of construction in buildings within the scope of the policy. It is therefore likely to slow down the use of engineered timber in future development in the medium to long term.

IBC Mass Timber Construction Types



IBC 2021 Fire Rating Requirements

Building Element	**I-A** *Unlimited stories, heights and areas**	**IV-A** *Max. 18 stories, 270 ft, 324,000 sf***	**I-B** *Max. 12 stories, 180 ft, unlimited areas**	**IV-B** *Max. 12 stories, 180 ft, 216,000 sf***	**IV-C** *Max. 9 stories, 85 ft, 135,000 sf***
Primary Frame	3	3	2	2	2
Exterior Bearing Walls	3	3	2	2	2
Interior Bearing Walls	3	3	2	2	2
Roof Construction	1.5	1.5	1	1	1
Primary Frame at Roof	2	2	1	1	1
Floor Construction	2	2	2	2	2

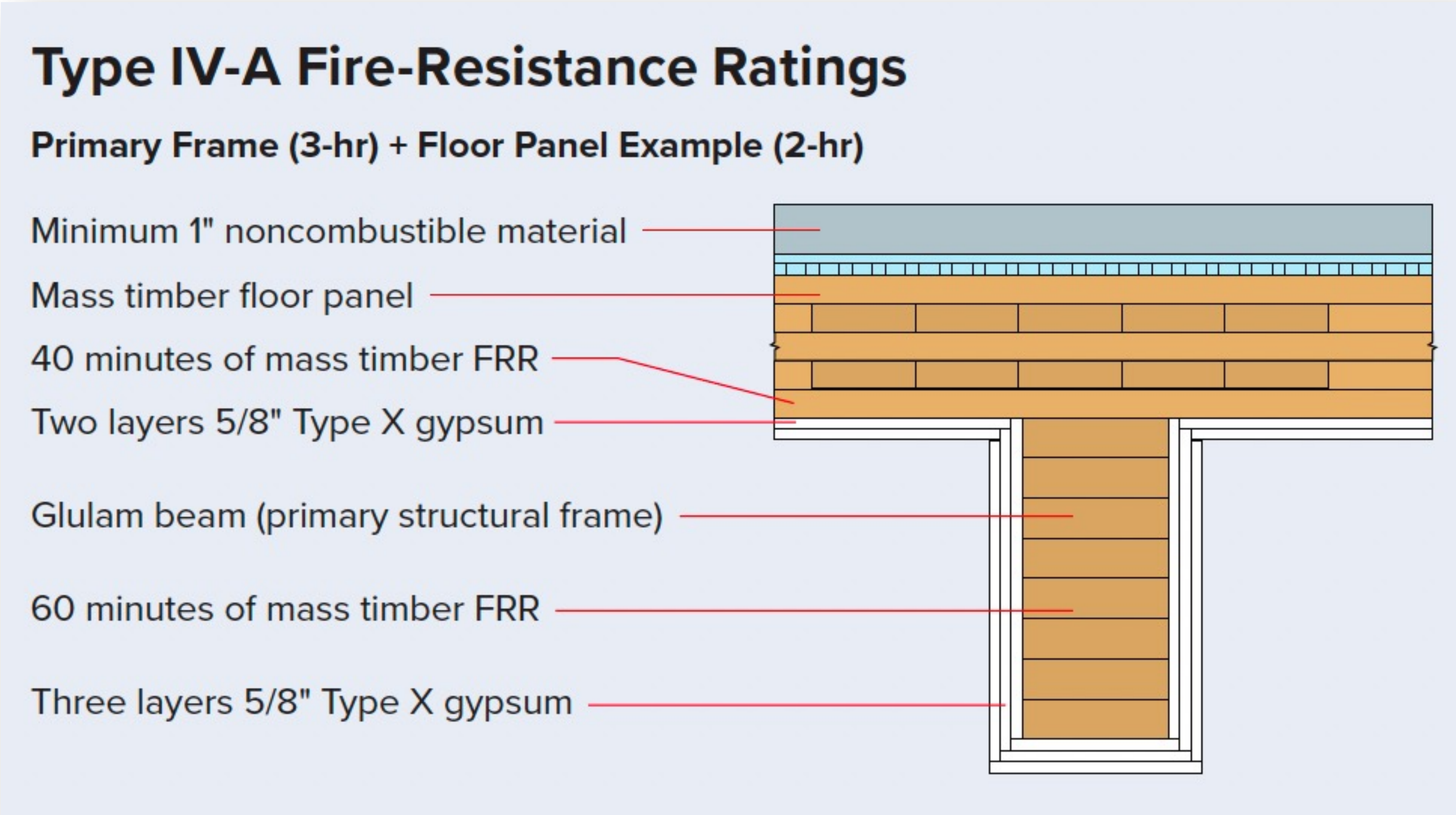
Assumes an NFPA 13 automatic sprinkler system throughout building

Source: 2021 IBC Tables 504.3, 504.4, 506.2 and 601

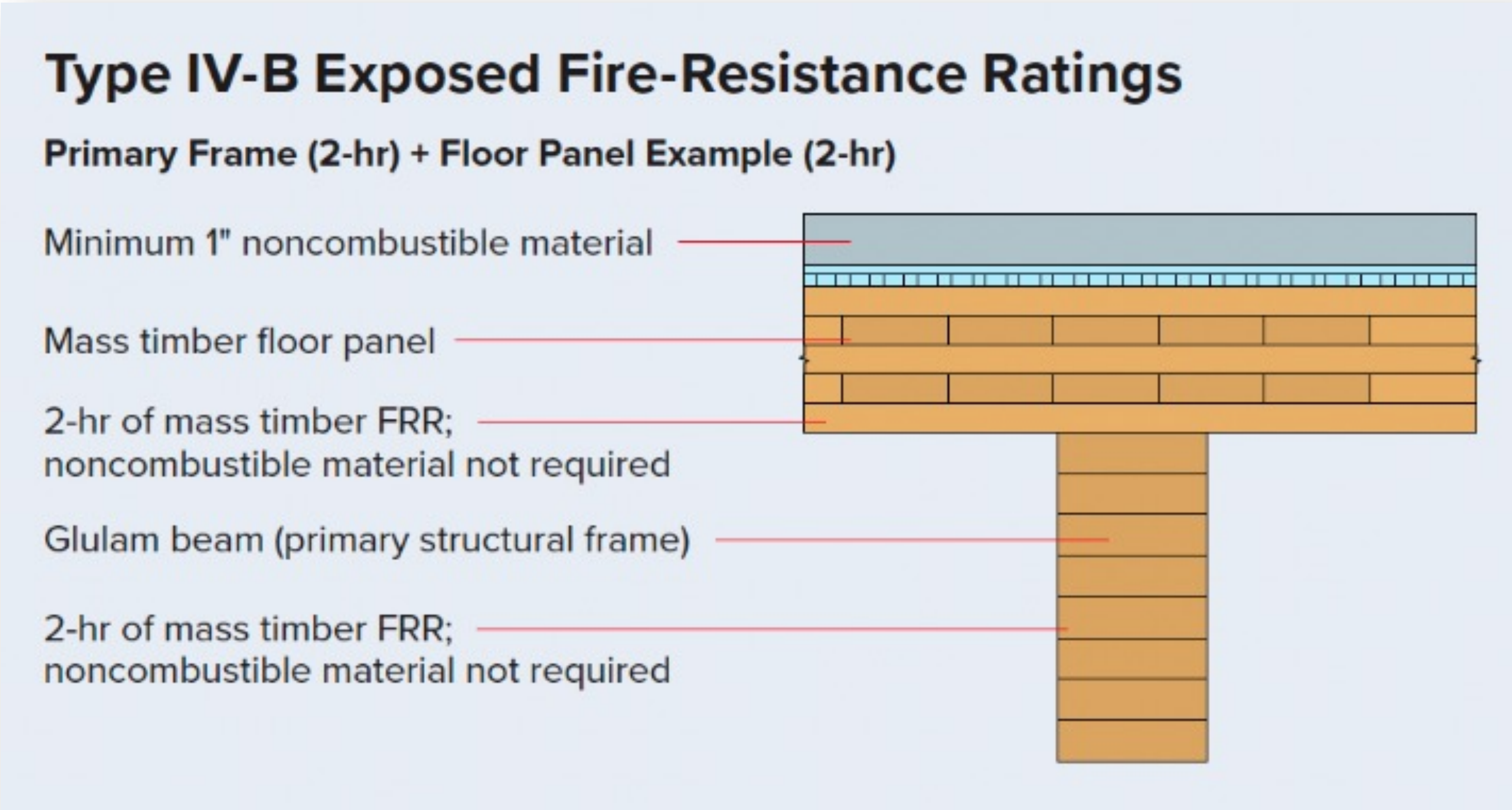
*Unlimited building size permitted for most occupancies

**Area limits indicated are per level, assuming no frontage increase; see IBC Tables 504.3, 504.4 and 506.2 for additional details

IBC 2021 Fire Rating Requirements



IBC 2021 Fire Rating Requirements



Performance-Based Approach

Height	Low-rise	Mid-rise	Tall	Very tall	High-rise
Stories	1–2	3–5	6–8	9–15	>15
Likely escape	Quick escape	Slow escape	Assisted escape	Assisted escape	Difficult escape
No sprinklers	Local areas exposed	No exposed wood	Not allowed	Not allowed	Not allowed
Normal sprinklers	Large areas exposed	Local areas exposed	No exposed wood	Full encapsulation	Full encapsulation
Special sprinklers	Large areas exposed	Large areas exposed	Local areas exposed	No exposed wood	Full encapsulation

Table replicated from Buchanan (2015), showing fire protection based on building height and area of mass timber exposed.

Performance-Based Approach

Fire Testing

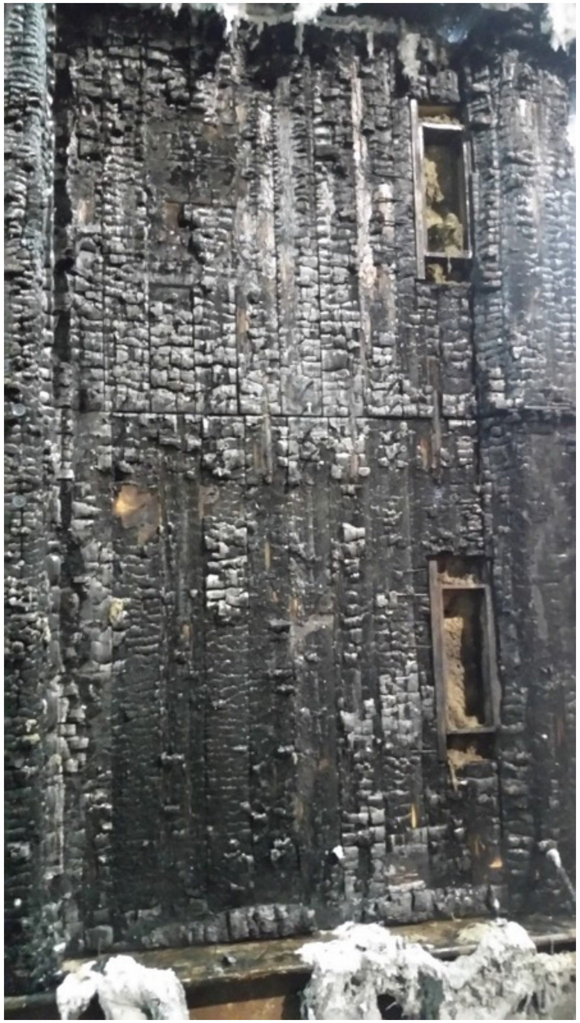
Performance-Based Approach

Fire Testing

Fire Regrowth Potential – Under-Tested Situation

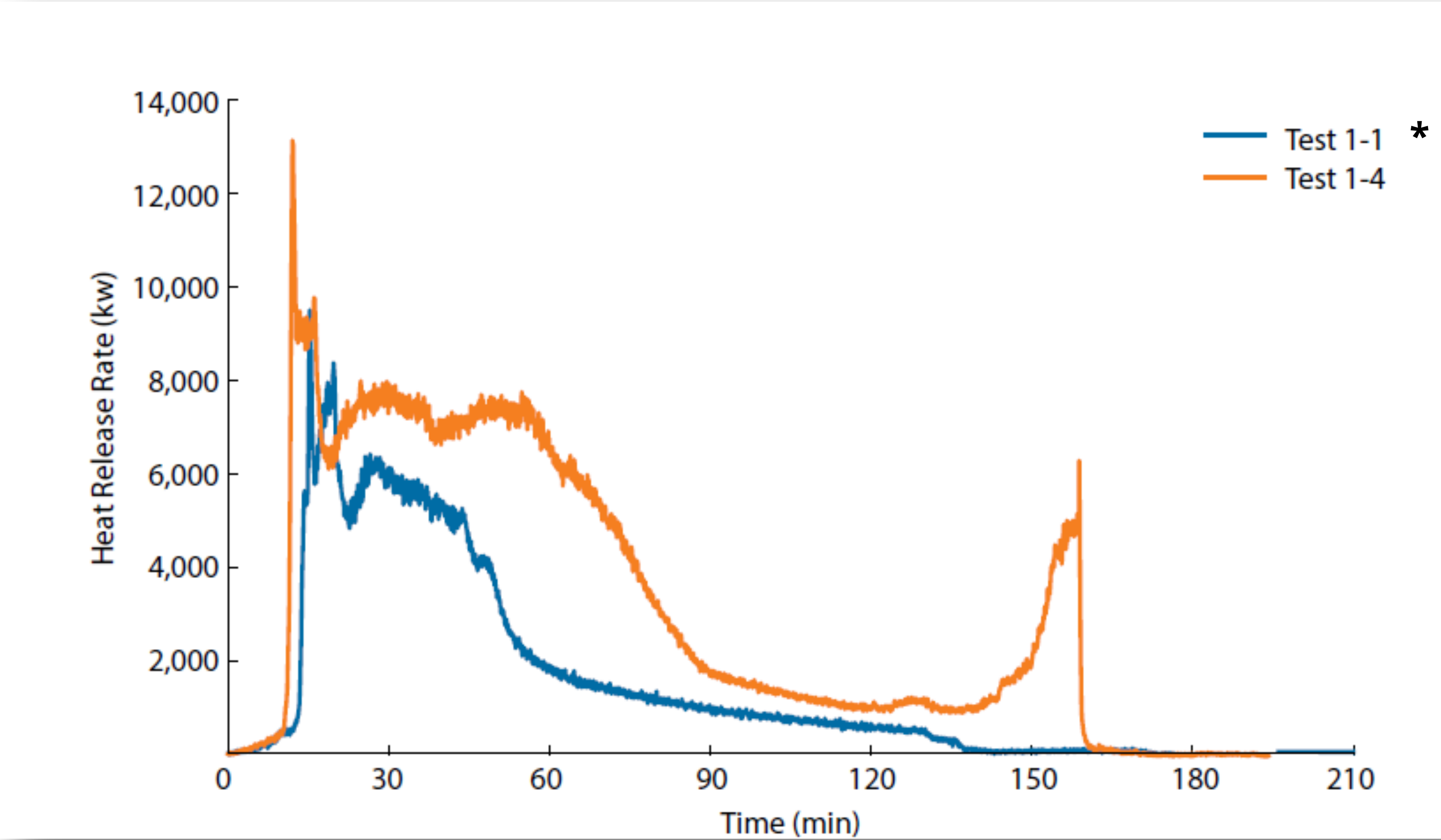
"Of concern is the unpredictability of fire regrowth, if there are large amounts of exposed CLT with adhesives that are prone to char debonding under heating."

- David Barber, Fire Engineer, Arup



Exposed mass timber in a fully-developed fire has been explored through full-scale fire testing, but only in compartments of up to 90 square meters of floor area.

Fire Regrowth Potential – Under-Tested Situation



* Test 1-1: No exposed timber; Test 1-4: CLT Exposed

Fire Testing vs. Proposed and Constructed Buildings

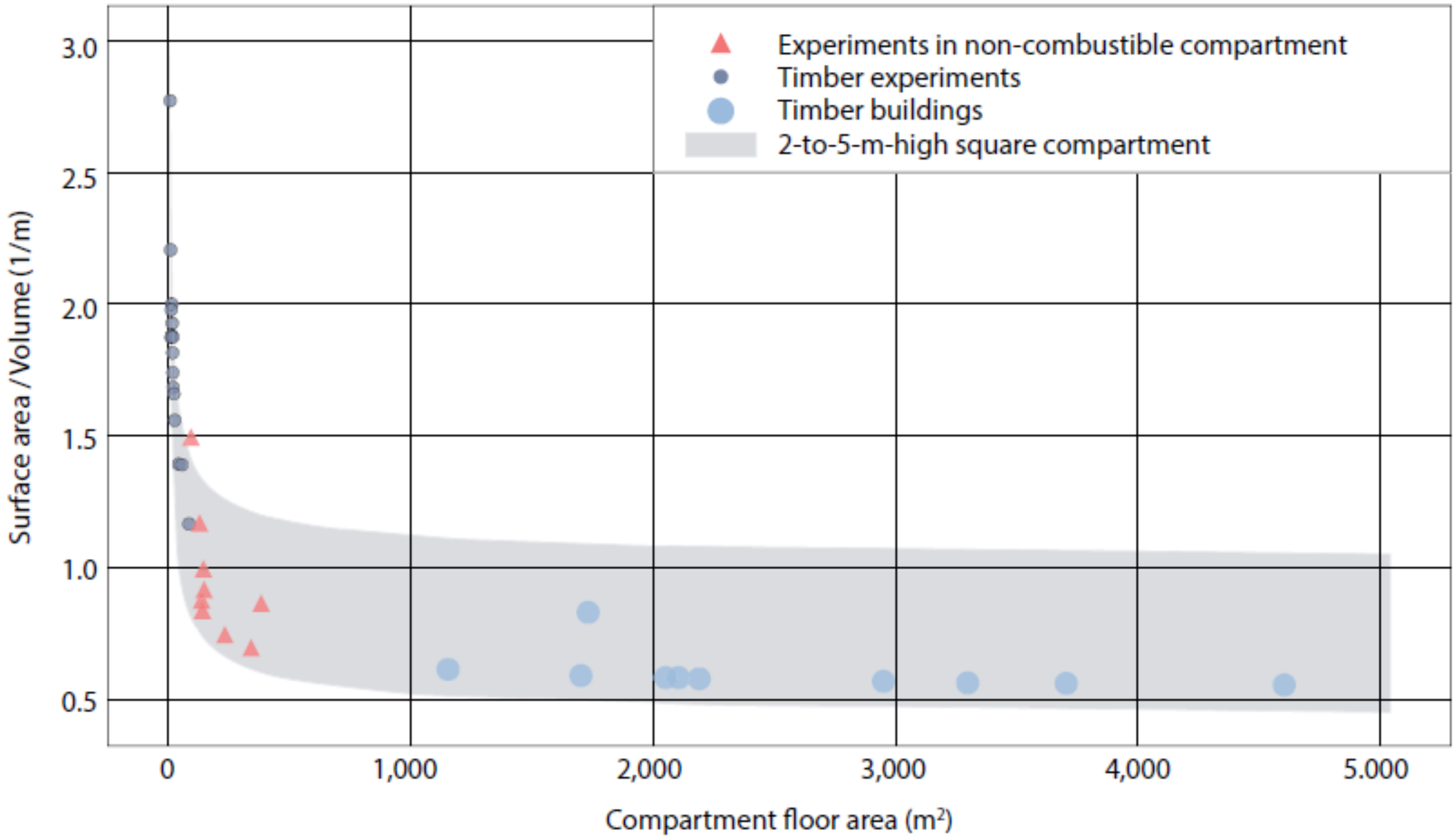


Figure 10. Graph illustrating the discrepancy between the available timber compartment fire tests and the proposed or constructed high-rise mass timber buildings.

Still Aiming High:

Tall Timber

Ascent:
The Tallest Mass Timber Building in the World

Milwaukee, USA
Completion: 2022

Height: 86.6 m; 25 floors
Structure: Concrete-Timber Hybrid

Ascent: The Tallest Mass Timber Building in the World

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Completion: 2022
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Still Aiming High

dezeen Next story

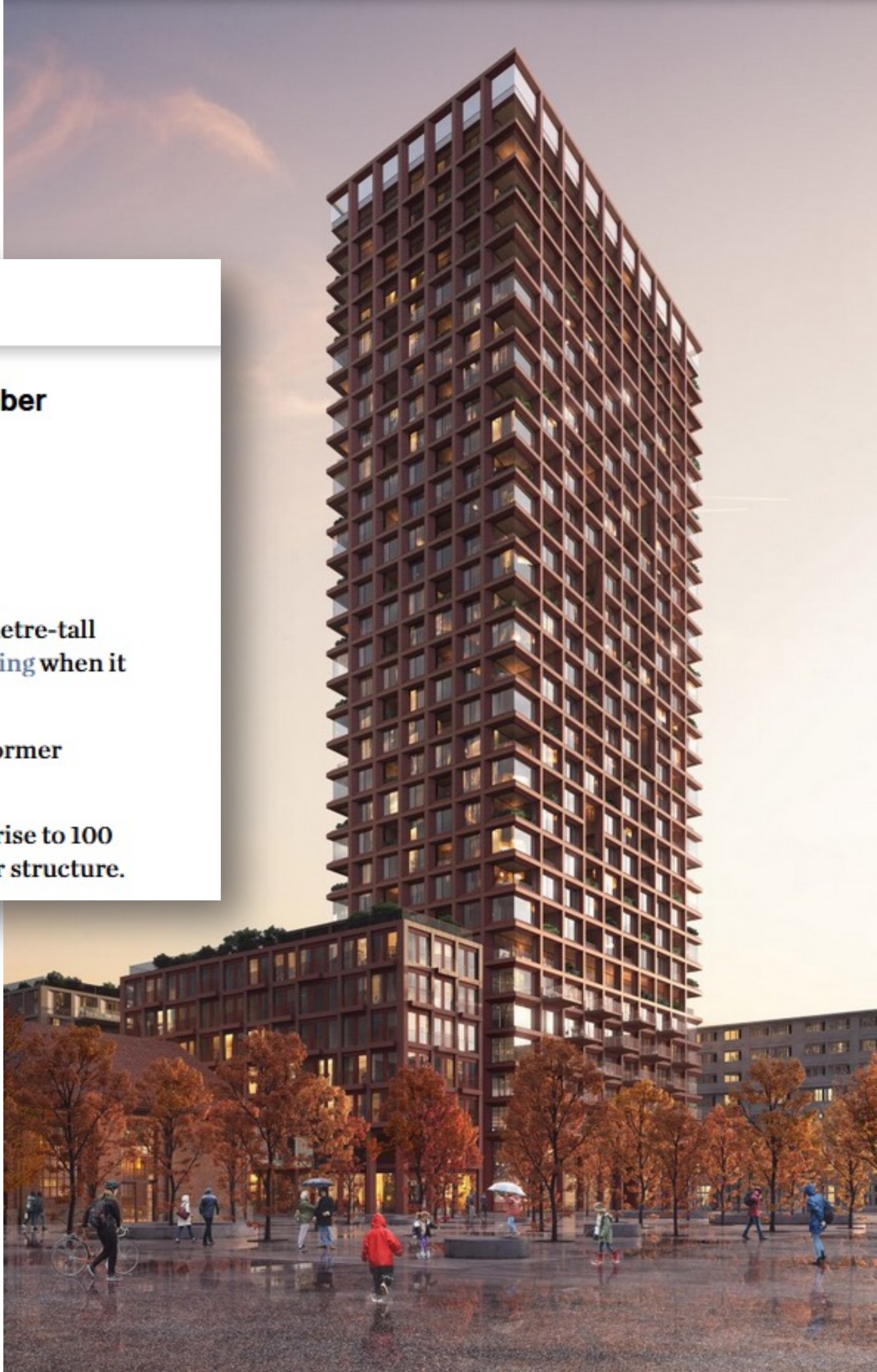
Schmidt Hammer Lassen unveils design for world's tallest timber building

James Parkes | 14 April 2022 | 22 comments

Danish studio Schmidt Hammer Lassen has revealed its design for a 100-metre-tall housing block in Switzerland, which will be the world's tallest timber building when it completes.

Named Rocket&Tigerli, the terracotta-clad building is set to be built on a former industrial site in the city of Winterthur, near Zurich.

It will be comprised of four volumes of different heights, one of which will rise to 100 metres tall making it the world's tallest building with a load-bearing timber structure.



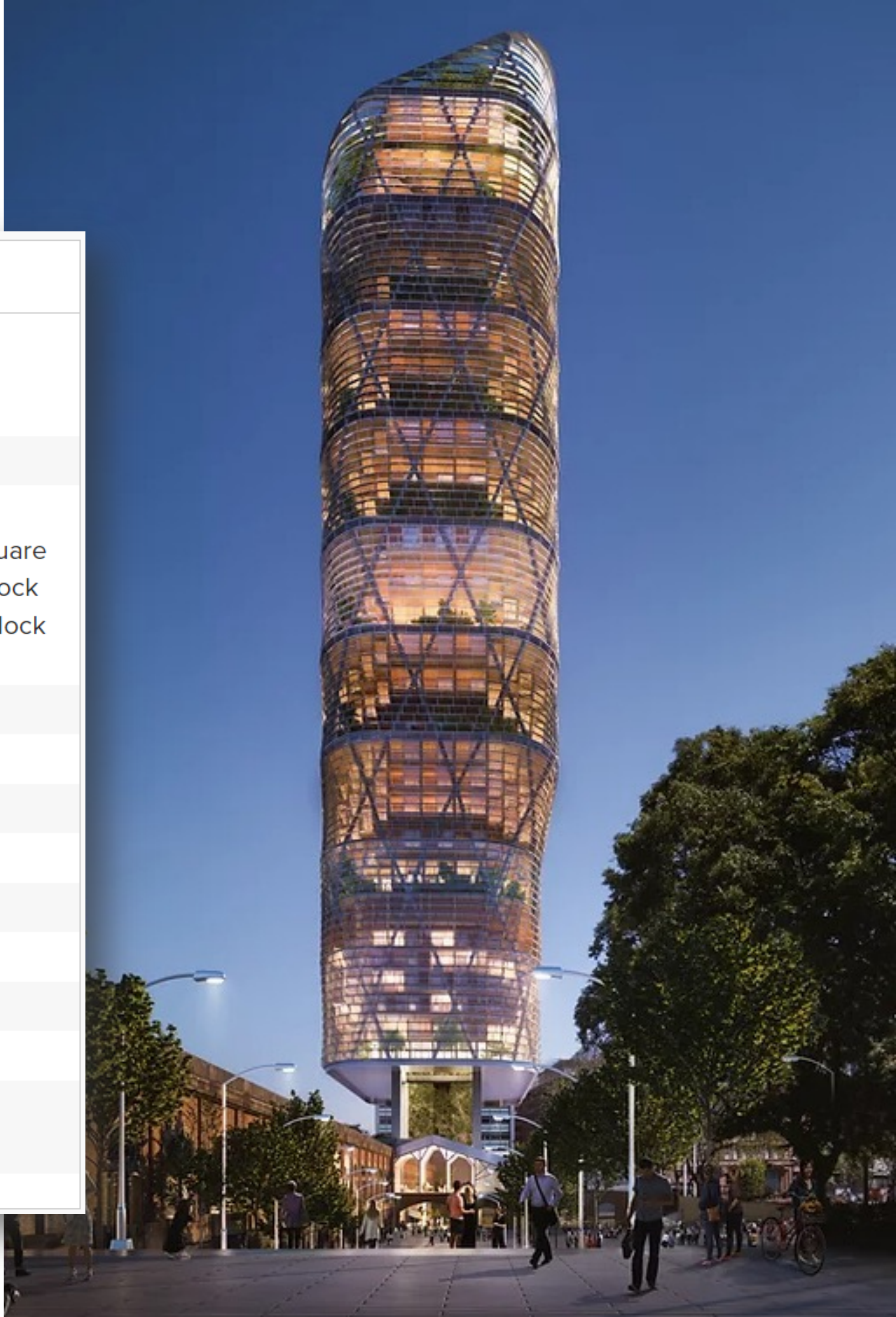
Still Aiming High

FACTS | METRICS

HEIGHT 182.6 m / 599 ft

FLOORS 42

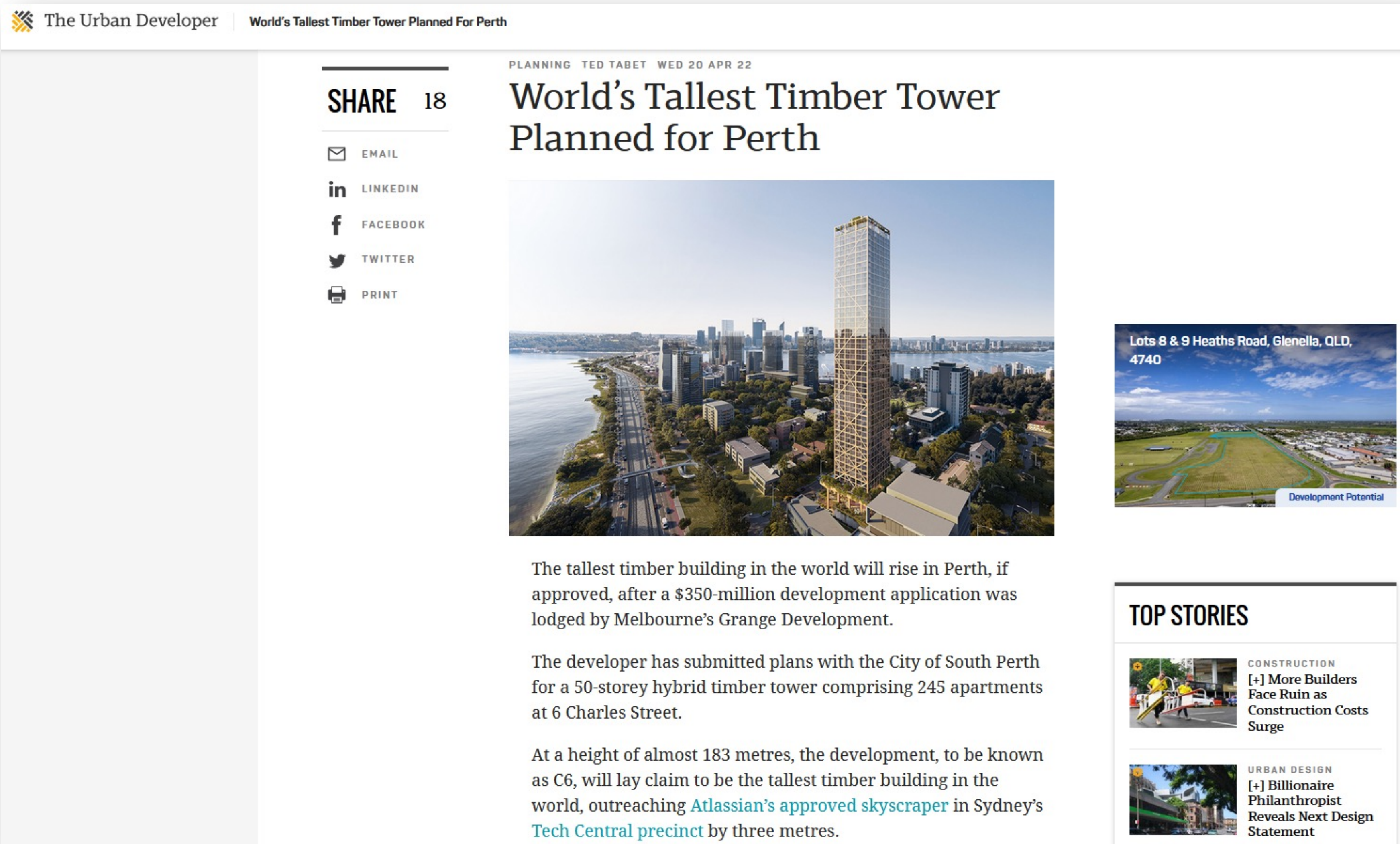
Official Name	Atlassian Central
Other Names	Atlassian Global Headquarters, Railway Square YHA, Western Gateway Block A, Central Place Sydney Block A
Name of Complex	Central Place Sydney
Type	Building
Status	UC Under Construction
Expected Completion	2027
Country	Australia
City	Sydney
Address	8-10 Lee Street
Function	Office / Hotel
Structural Material	Concrete-Steel-Timber Composite



Atlassian Central:

Potential Future Tallest Mass Timber Building in the World
(Currently Under Construction)

Still Aiming High



The Urban Developer | World's Tallest Timber Tower Planned For Perth

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PLANNING TED TABET WED 20 APR 22

World's Tallest Timber Tower Planned for Perth

The tallest timber building in the world will rise in Perth, if approved, after a $350-million development application was lodged by Melbourne's Grange Development.

The developer has submitted plans with the City of South Perth for a 50-storey hybrid timber tower comprising 245 apartments at 6 Charles Street.

At a height of almost 183 metres, the development, to be known as C6, will lay claim to be the tallest timber building in the world, outreaching Atlassian's approved skyscraper in Sydney's Tech Central precinct by three metres.

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The Future Potential of Steel-Timber Hybrid Buildings

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Project Completion: December 2023

constructsteel

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Coming in 2024…

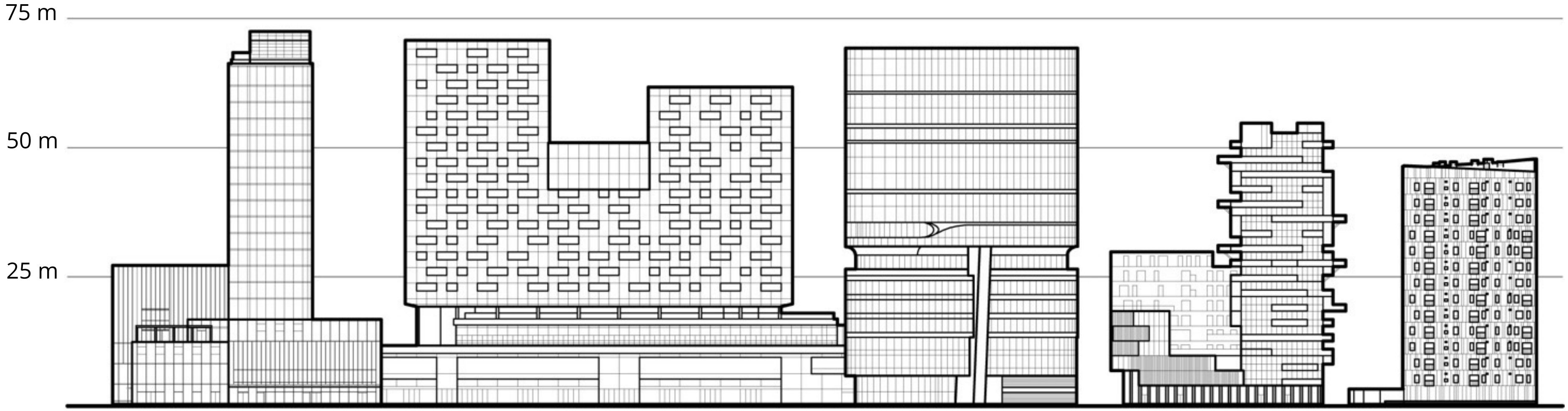
Includes:

- **Detailed Case Studies**
- **Data!**
- **Full LCA Scenarios**
- **Recommendations/Methodology**

See:
ctbuh.org/research/projects/the-future-potential-of-steel-timber-hybrid-buildings

The Future Potential of Steel-Timber Hybrid Buildings:

World's 5 Tallest Mass Timber Buildings Employing Steel



Sara Kulturhus
2021
Skellefteå
72.8 m

De Karel Doorman
2012
Rotterdam
70.5 m

55 Southbank
2020
Melbourne
69.7 m

Hyperion
2021
Bordeaux
55.0 m

Lighthouse
2019
Joensuu
48.0 m

The Future Potential of Steel-Timber Hybrid Buildings:

The Initial Case for Steel-Timber Hybrid Buildings

Assumptions being tested by current CTBUH research

- Greater spanning strength and ductility (than timber alone)?
- Better lateral restraint systems, especially for taller buildings?
- Better Carbon / LCA implications (than concrete-timber hybrid)?
- More flexibility with layouts, and later renovations / change of use?
- Ease of assembly and lower weight (than concrete-timber hybrid)?
- Greater dimensional accuracy, steel akin to mass timber?
- The greater potential for aesthetic expression of timber / biophilic benefits?

Greater spanning strength and ductility

Building: 843 N. Spring Street

Location: Los Angeles, California

Floors: 5

Function: Office

Status: Complete

Better suitability for lateral restraint systems

Building: Atlassian Central

Location: Sydney, Australia

Height: 182.6m

Function: Mixed-Use
(Office over Hotel)

Status: Under Construction

Better life cycle assessment implications

Building: Sara Kulturhus

Location: Skellefteå, Sweden

Height: 72.8m

Function: Mixed-Use

Status: Complete (2021)

More flexibility for layouts, renovations, future use

Building: De Karel Doorman

Location: Rotterdam, Netherlands

Height: 70.5

Function: Residential / Retail

Status: Completed

Lower weight for greater height

Building: 55 Southbank

Location: Melbourne, Australia

Height: 69.7m

Function: Mixed-Use (Hotel over Office)

Status: Complete (2020)

Greater dimensional accuracy

Building: Opalia

Location: Paris, France

Floors: 8

Function: Office

Status: Complete (2017)

Aesthetic expression of timber and biophilic benefits

Building: Ascent

Location: Milwaukee, Wisconsin

Height: 86.6m

Function: Residential

Status: Completed (2022)

Inherent Fire Resistance

Building: Terminus

Location: Victoria, Canada

Floors: 5

Function: Office

Status: Complete

Better Floor-to-Floor Heights

Building: Opalia

Location: Paris, France

Floors: 8

Function: Office

Status: Complete (2017)

The Future Potential of Steel-Timber Hybrid Buildings:

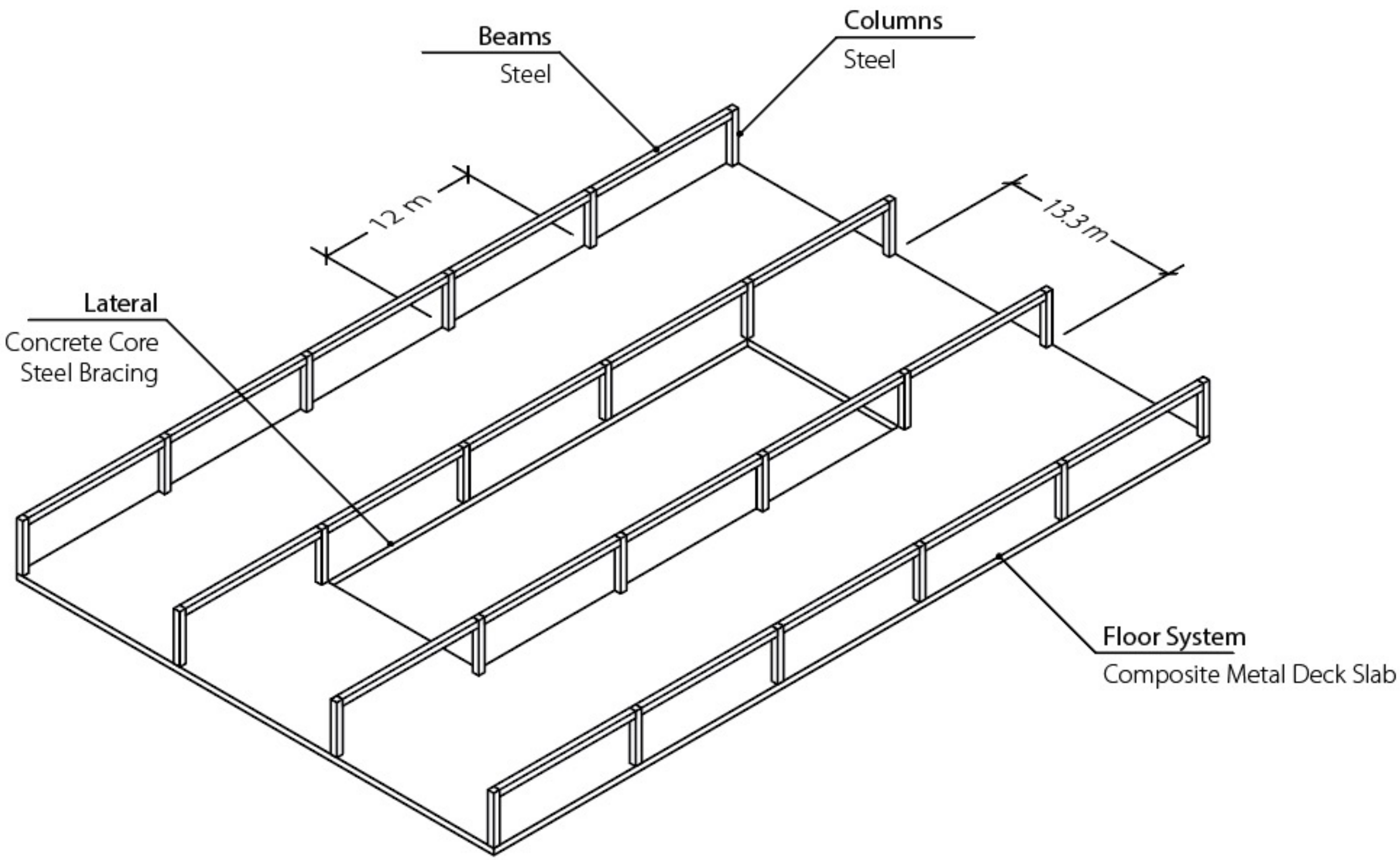
Parameters of Steel-Timber Life Cycle Carbon and Cost Assessment (LCCA)

- **Material & Structural System Comparisons**
- **Real vs. Generic Scenarios**
- **Whole Building vs Structure**
- **Location**
- **Height / Floor Count**
- **Function**
- **Embodied vs Operating**
- **Whole life / end-of-life**
- **Platform(s) / Software(s)**

The Future Potential of Steel-Timber Hybrid Buildings:

Structural Engineering Design Scenarios

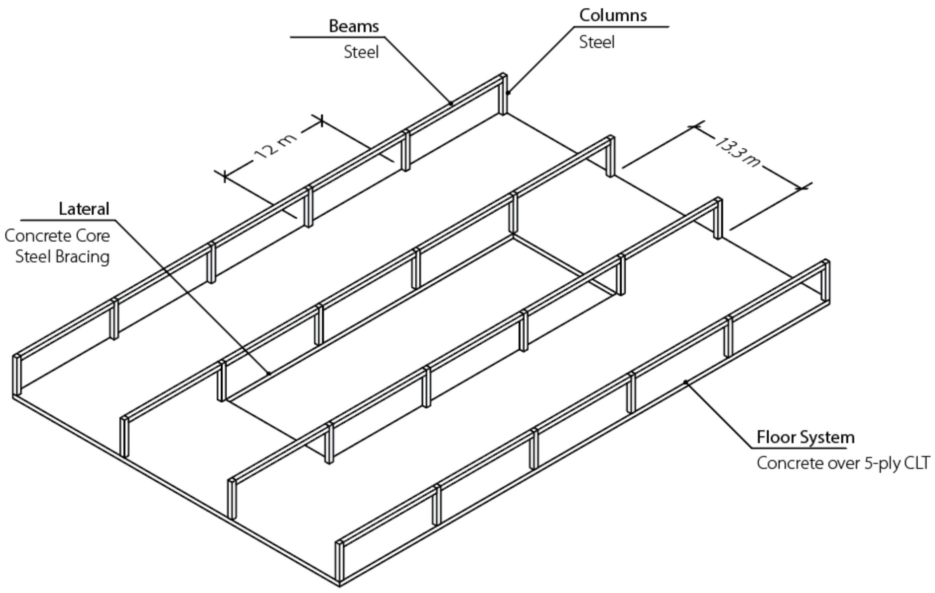
20 Stories (Scenario 1) and 40 Stories (Scenario 2)

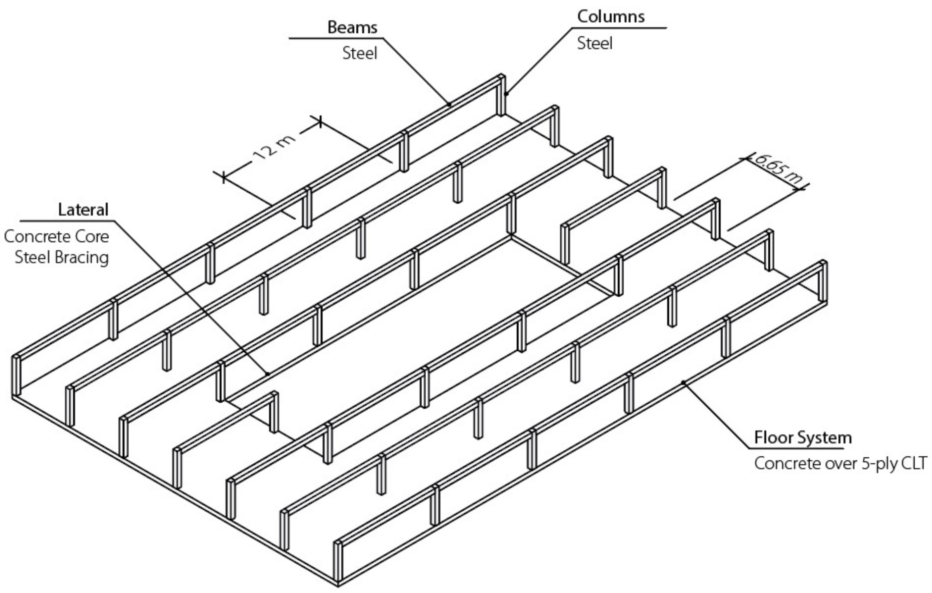


The Future Potential of Steel-Timber Hybrid Buildings:

Structural Engineering Design Scenarios

- **20 Stories (Scenario 3) and 40 Stories (Scenario 4)**
- **Steel Beams Only (3a & 4a); Steel Beams w/ Secondary Timber Beams (3b & 4b)**

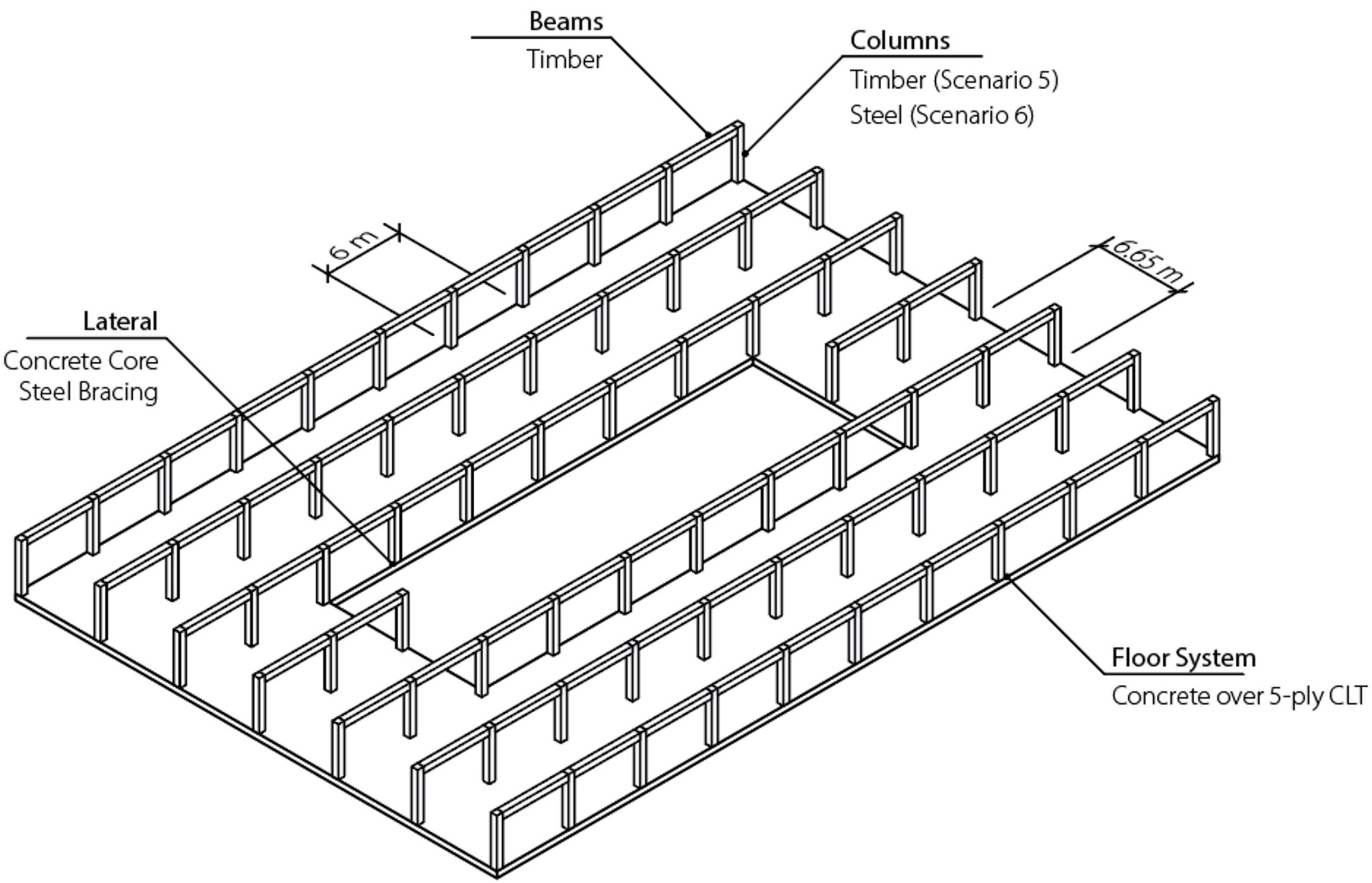




The Future Potential of Steel-Timber Hybrid Buildings:

Structural Engineering Design Scenarios

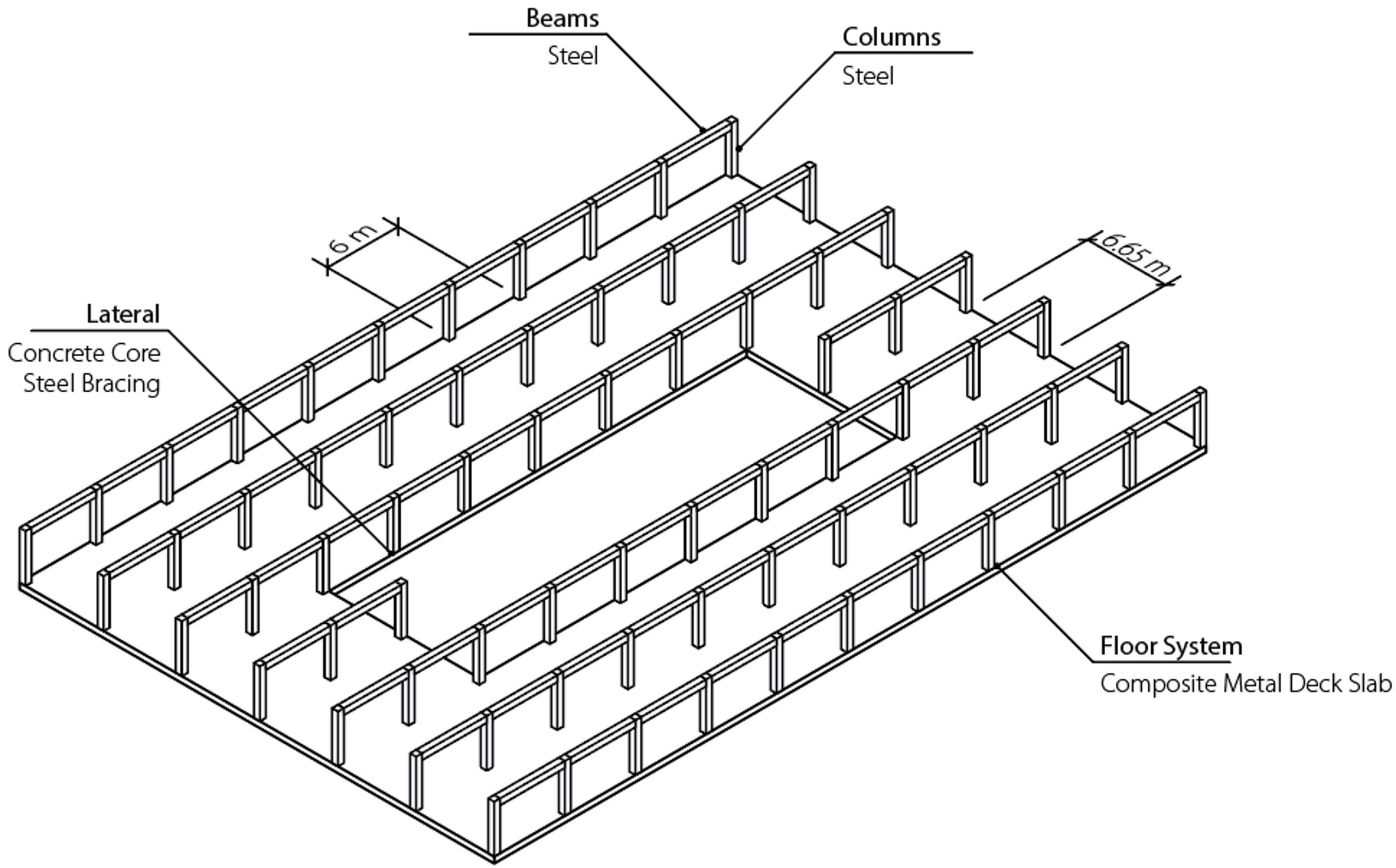
20 Stories/Timber Columns (Scenario 5) and 40 Stories/Steel Columns (Scenario 6)



The Future Potential of Steel-Timber Hybrid Buildings:

Structural Engineering Design Scenarios

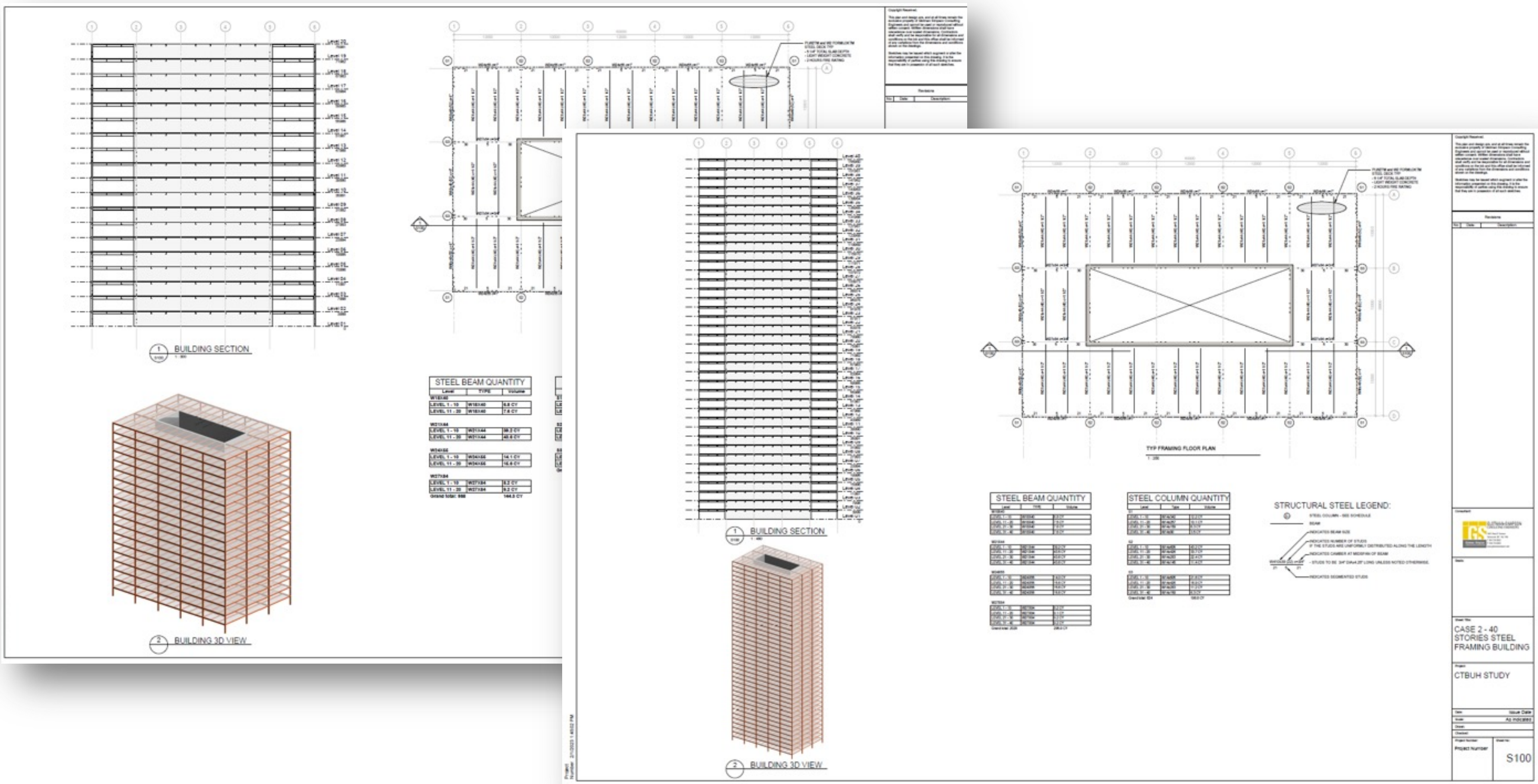
20 Stories (Scenario 7) and 40 Stories (Scenario 8)



The Future Potential of Steel-Timber Hybrid Buildings:

Designs Developed by Structural Engineering Working Group

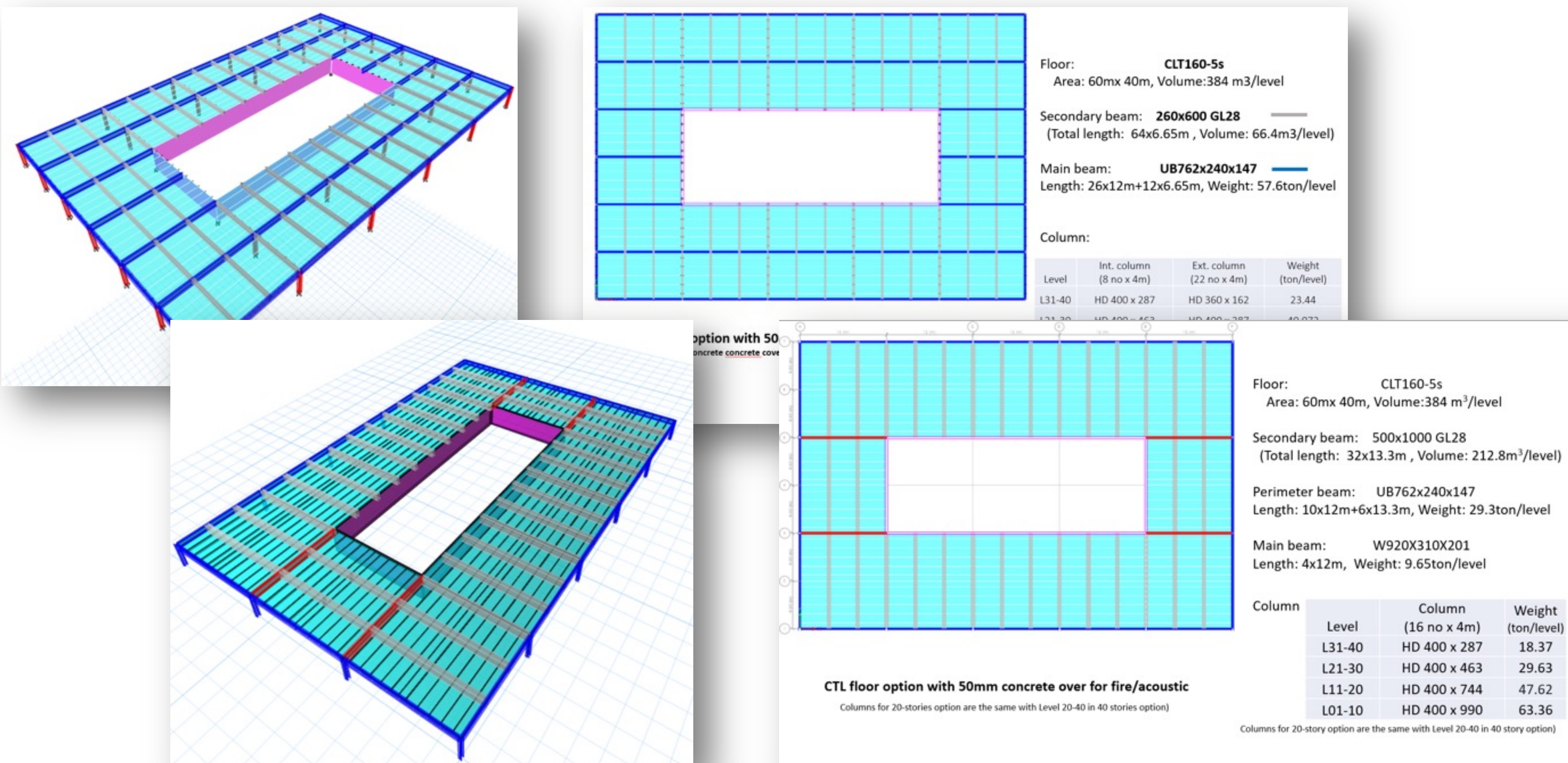
20 Stories (Scenario 1) and 40 Stories (Scenario 2)



The Future Potential of Steel-Timber Hybrid Buildings:

Designs Developed by Structural Engineering Working Group

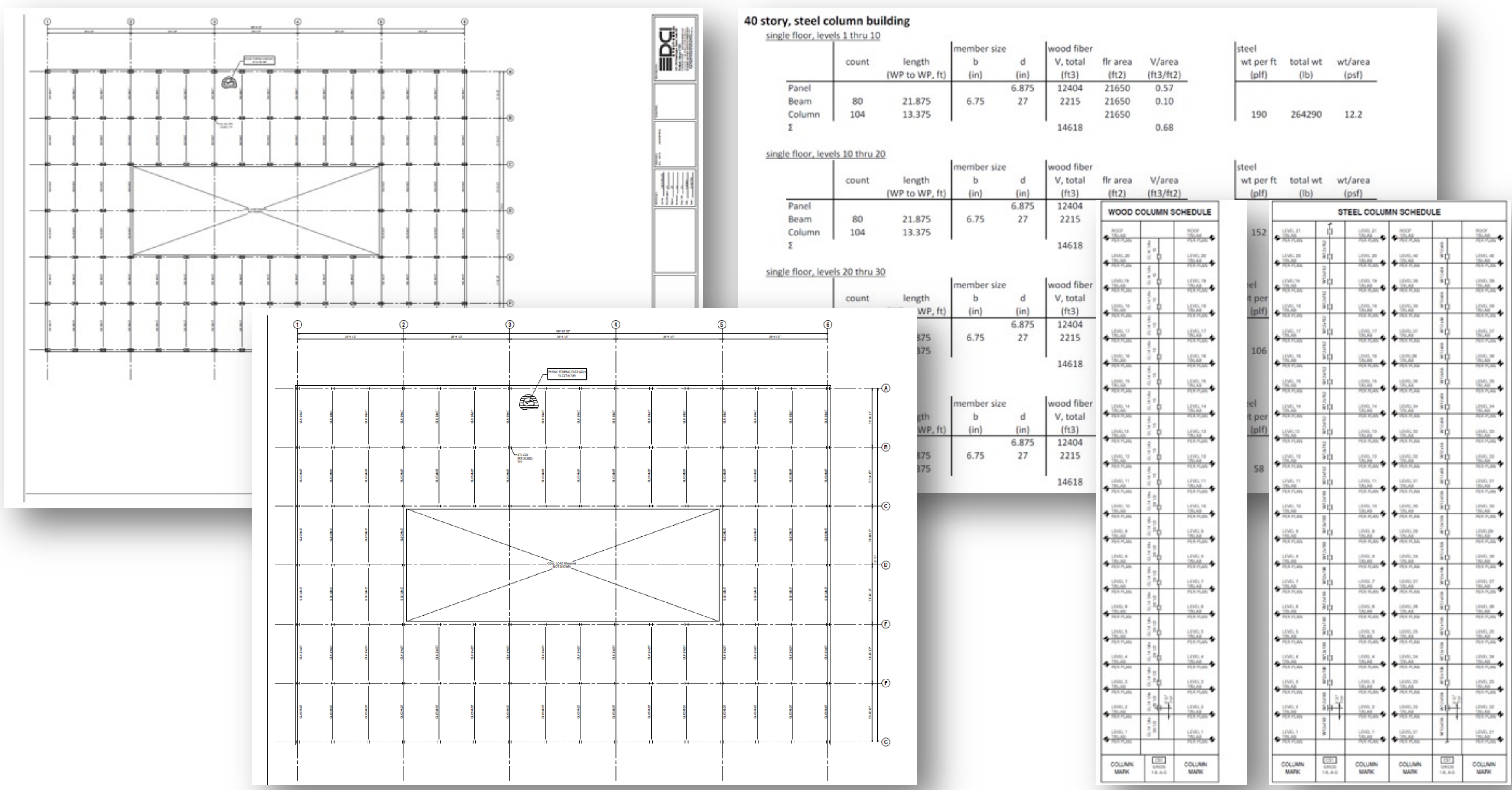
- **20 Stories (Scenario 3) and 40 Stories (Scenario 4)**
- **Steel Beams Only (3a & 4a); Steel Beams w/ Secondary Timber Beams (3b & 4b)**



The Future Potential of Steel-Timber Hybrid Buildings:

Designs Developed by Structural Engineering Working Group

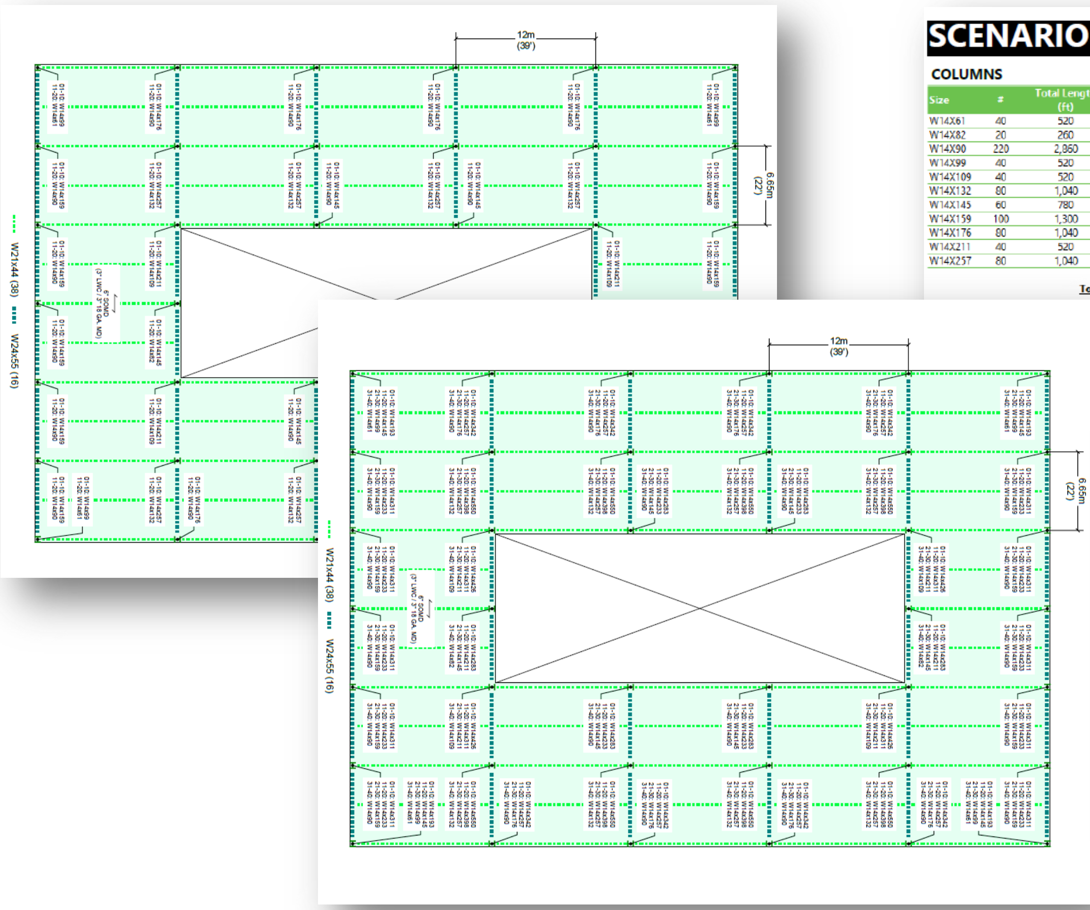
20 Stories/Timber Columns (Scenario 5) and 40 Stories/Steel Columns (Scenario 6)



The Future Potential of Steel-Timber Hybrid Buildings:

Designs Developed by Structural Engineering Working Group

20 Stories (Scenario 7) and 40 Stories (Scenario 8)



SCENARIO 7 - SUBDIVIDED - 20 STORIES

COLUMNS

Size	#	Total Length (ft)	Weight (lbs)
W14X61	40	520	31,673
W14X82	20	260	21,233
W14X90	220	2,860	257,897
W14X99	40	520	51,491
W14X109	40	520	56,622
W14X132	80	1,040	137,309
W14X145	60	780	113,333
W14X159	100	1,300	206,583
W14X176	80	1,040	183,314
W14X211	40	520	109,706
W14X257	80	1,040	267,540
		Total	**1,436,701**

BEAMS

Size	#	Total Length (ft)	Weight (lbs)
W21X44	1,120	43,680	1,932,233
W24X55	640	14,080	776,160
		Total	**2,708,393**

SCENARIO 8 - SUBDIVIDED - 40 STORIES

COLUMNS

Size	#	Total Length (ft)	Weight (lbs)
W14X61	40	520	31,673
W14X82	20	260	21,233
W14X90	280	3,640	328,232
W14X99	40	520	51,491
W14X109	40	520	56,622
W14X132	80	1,040	137,309
W14X145	100	1,300	188,888
W14X159	100	1,300	206,583
W14X176	80	1,040	183,314
W14X193	40	520	100,504
W14X211	60	780	164,558
W14X233	110	1,430	333,319
W14X257	160	2,080	535,080
W14X283	30	390	110,546
W14X311	140	1,820	566,045
W14X342	80	1,040	357,428
W14X398	80	1,040	414,050
W14X426	40	520	221,181
W14X550	80	1,040	573,300
		Total	**4,581,356**

BEAMS

Size	#	Total Length (ft)	Weight (lbs)
W21X44	2,240	87,360	3,864,467
W24X55	1,280	28,160	1,552,320
		Total	**5,416,787**

The Future Potential of Steel-Timber Hybrid Buildings:

Evaluations and Comparison Being Conducted

Vertical

Scenario	Grid	Stories	Lateral	Type	Floors	Schedule	Volume m3	Volume yd3	Density kg/m3	Density lb/yd3	Weight kg	Weight lb
1	2015 Grid	20	Concrete Core	Steel Columns	1 to 10	W14X159	4.82	6.30				
						W14X283	25.69	33.60				
					11 to 20	W14X90	2.45	3.20				
						W14X159	8.64	11.30				
						W14X145	3.98	5.20				
						TOT.	**45.57**	**59.60**	**7800**		**355426.26**	**783579.85**
2	2015 Grid	40	Concrete Core	Steel Columns	1 to 10	W14X342	9.33	12.20				
						W14X605	49.54	64.80				
					11 to 20	W14X257	7.72	10.10				
						W14X426	38.69	50.60				
					21 to 30	W14X159	4.82	6.30				
						W14X283	25.69	33.60				
					31 to 40	W14X90	2.68	3.50				
						W14X145	8.72	11.40				
						W14X159	4.82	6.30				
						TOT.	**151.99**	**198.80**	**7800**		**1185549.35**	**2613685.80**
3	2015 Grid	20	Concrete Core	Steel Columns	1 to 10	W14X257	30.92	40.44				
						TOT.						
					11 to 20	W14X132	15.86	20.74				
						TOT.						
						TOT.	**46.78**	**61.19**	**7800**		**364884**	**804430.56**
4	2015 Grid	40	Concrete Core	Steel Columns	1 to 10	W14X550	66.24	86.64				
						TOT.						
					11 to 20	W14X398	47.84	62.57				
						TOT.						
					21 to 30	W14X257	30.92	40.44				
						TOT.						
					31 to 40	W14X132	15.86	20.74				
						TOT.						
						TOT.	**160.86**	**210.40**	**7800**		**1254708**	**2766154.35**
5	Subdivided	20	Concrete Core	Timber Columns	1 to 10	GL141/4X 28 1/2	1110.87	1452.96				
					11 to 20	GL141/4X 15	584.74	764.81				
						TOT.	**1695.61**	**2217.78**	**750**		**1271709.68**	**2803636.60**
6	Subdivided	40	Concrete Core	Steel Columns	1 to 10	W12X190	15.27	19.97				
					11 to 20	W12X152	12.22	15.98				
					21 to 30	W12X106	8.52	11.14				
					31 to 40	W12X58	4.66	6.10				
						TOT.	**40.67**	**53.19**	**7800**		**317223.66**	**703846**
7	Subdivided	20	Concrete Core	Steel Columns	1 to 10	W14X99	2.97	3.88				
						W14X159	11.94	15.62				
						W14X176	10.59	13.85				
						W14X257	15.46	20.22				
						W14X211	6.34	8.29				
						W14X145	6.55	8.57				
					11 to 20	W14X61	1.83	2.39				
						W14X82	1.23	1.61				
						W14X90	14.90	19.49				
						W14X109	3.27	4.28				
						W14X132	7.93	10.37				
						TOT.	**83.01**	**108.57**	**7800**		**651676.61**	**1436701**
8	Subdivided	40	Concrete Core	Steel Columns	1 to 10	W14X193	5.80	7.59				
						W14X283	6.39	8.36				
						W14X311	23.36	30.56				
						W14X342	20.65	27.01				
						W14X426	12.78	16.72				
						W14X550	33.12	43.32				
					11 to 20	W14X145	4.36	5.70				
						W14X211	3.17	4.15				
						W14X233	19.26	25.19				
						W14X257	15.46	20.22				
						W14X311	9.35	12.22				
						W14X398	23.92	31.29				
					21 to 30	W14X99	2.97	3.88				
						W14X159	11.93	15.60				
						W14X176	10.59	13.85				
						W14X257	15.46	20.22				
						W14X211	6.34	8.29				
						W14X145	6.55	8.57				
					31 to 40	W14X61	1.83	2.39				
						W14X82	1.22	1.60				
						W14X90	18.97	24.81				
						W14X109	3.27	4.28				
						W14X132	7.93	10.37				
						TOT.	**264.72**	**346.24**	**7800**		**2078068.13**	**4581356**

Horizontal

Scenario	Type	Floors	Schedule	Volume m3	Volume yd3	Density kg/m3	Density lb/yd3	Weight kg	Weight lb
1	Steel Beams	1 to 10	W18X40	5.20	6.80				
			W21X44	29.97	39.20				
			W24X55	10.78	14.10				
			W27X84	6.27	8.20				
		11 to 20	W18X40	5.81	7.60				
			W21X44	33.33	43.60				
			W24X55	11.93	15.60				
			W27X84	7.03	9.20				
			TOT.	**110.33**	**144.30**	**7800**		**860537.07**	**1897157.25**
2	Steel Beams	1 to 10	W18X40	5.20	6.80				
			W21X44	29.97	39.20				
			W24X55	10.70	14.00				
			W27X84	6.27	8.20				
		11 to 20	W18X40	5.73	7.50				
			W21X44	33.26	43.50				
			W24X55	11.93	15.60				
			W27X84	6.96	9.10				
		21 to 30	W18X40	5.81	7.60				
			W21X44	33.33	43.60				
			W24X55	11.93	15.60				
			W27X84	7.03	9.20				
		31 to 40	W18X40	5.81	7.60				
			W21X44	33.33	43.60				
			W24X55	11.93	15.60				
			W27X84	7.03	9.20				
			TOT.	**226.23**	**295.90**	**7800**		**1764607.90**	**3890289.88**
3	Steel Beams	1 to 20	W27X84	123.91	162.06				
			W27X102	46.45	60.76				
			W27X129	23.41	30.62				
			TOT.	**193.77**	**253.44**	**7800**		**1511392.07**	**3332045.19**
4	Steel Beams	1 to 40	W27X84	426.67	558.06				
			W27X102	92.90	121.51				
			W27X129	46.82	61.24				
			TOT.	**566.39**	**740.81**	**7800**		**4417857.49**	**9739696.97**
5	Timber Beams	1 to 20	GL6 3/4 X 27	62.69	82.00				
			TOT.	**1253.87**	**1640.00**	**750**		**940402.48**	**2073230.11**
6	Timber Beams	1 to 40	GL6 3/4 X 27	62.72	82.04				
			TOT.	**2508.96**	**3281.60**	**750**		**1881722.42**	**4148482.87**
7	Steel Beams	1 to 20	W21X44	111.65	146.03				
			W24X55	44.84	58.66				
			TOT.	**156.49**	**204.69**	**7800**		**1228506.4**	**2708393**
8	Steel Beams	1 to 40	W21X44	223.29	292.00				
			W24X55	89.70	117.32				
			TOT.	**312.99**	**409.32**	**7800**		**2457013.25**	**5416787**

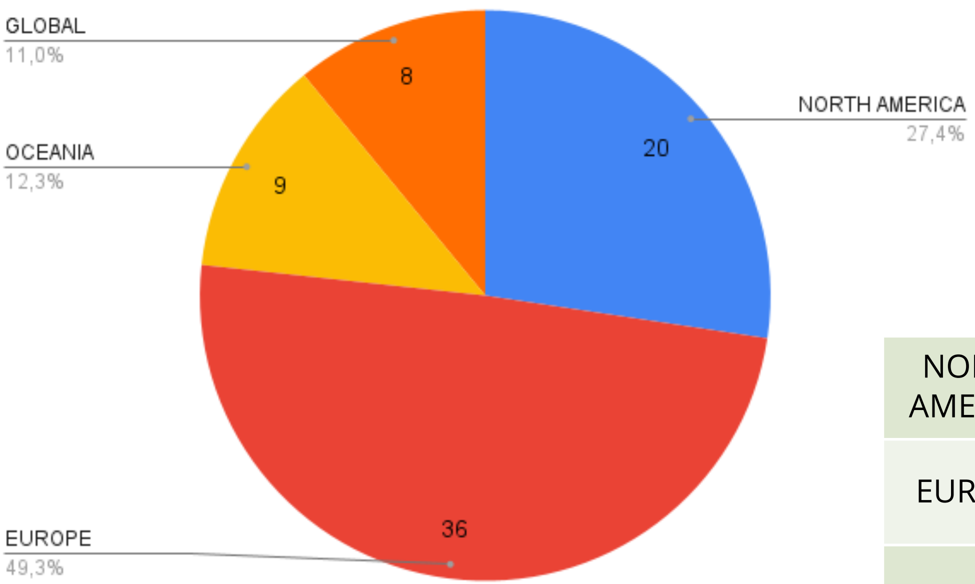
Floor Assembly

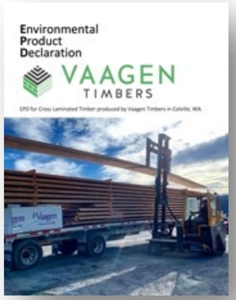
Scenario	Type	Material	Area m2	Area ft2	Volume m3	Volume yd3	Density kg/m3	Density lb/yd3	Weight kg	Weight lb	Firm
1	Composite Metal Deck Slab 5 1/4"	Lightweight concrete	38400	413333.76	4139.82	5414.67	1762.03	2970.00	**7294482.25**	**16081576.60**	Glotman Simpson; Thornton Tomasetti
		Metal deck	38400	413333.76					**506209.19**	**1116001.15**	
		Mesh?									
		Studs?									
2	Composite Metal Deck Slab 5 1/4"	Lightweight concrete	76800	826667.52	8279.64	10829.34	1762.03	2970.00	**14588964.50**	**32163153.20**	Glotman Simpson; Thornton Tomasetti
		Metal deck	76800	826667.52					**1012418.39**	**2232002.30**	
		Mesh?									
		Studs?									
3	Concrete over 7-ply CLT	2" (50.8 mm) Concrete topping	38400	413333.76	2227.20	2913.07	2322.68	3915.00	**5173062.96**	**11404654.33**	Fast+Epp; Taylor Thomson Whitting
		~8" (203.2 mm) Cross-laminated timber	38400	413333.76	7802.88	10205.78	500.00	842.78	**3901440.00**	**8601199.14**	
4	Concrete over 5-ply CLT	2" (50.8 mm) Concrete topping	76800	826667.52	4454.40	5826.13	2322.68	3915.00	**10346125.93**	**22809308.66**	Fast+Epp; Taylor Thomson Whitting
		~5" (127 mm) Cross-laminated timber	76800	826667.52	9753.60	12757.22	500.00	842.78	**4876800.00**	**10751498.92**	
5	Concrete over 5-ply CLT	3" (76.2 mm) Concrete topping	38400	413333.76	2926.08	3827.17	2322.68	3915.00	**6796334.44**	**14983356.21**	DCI Engineers; Mott MacDonald
		6 7/8" (174.6 mm) Cross-laminated timber	38400	413333.76	6704.64	8769.33	500.00	842.78	**3352320.00**	**7390597.29**	
6	Concrete over 5-ply CLT	3" (76.2 mm) Concrete topping	76800	826667.52	5852.16	7654.33	2322.68	3915.00	**13592668.89**	**29966712.41**	DCI Engineers; Mott MacDonald
		6 7/8" (174.6 mm) Cross-laminated timber	76800	826667.52	13409.28	17538.67	500.00	842.78	**6704640.00**	**14781194.58**	
7	6" Composite Metal Deck Slab (3" LWC / 3" 18 GA. MD)	Lightweight concrete	38400	413333.76	3760.60	4918.67	1762.03	2970.00	**6626285.40**	**14608455.08**	Buro Happold; Ramboll
		Metal deck	38400	413333.76					**506209.19**	**1116001.15**	
		Mesh?									
		Studs?									
										15724456.23	
										18310685.57	
										44.30	
8	6" Composite Metal Deck Slab (3" LWC / 3" 18 GA. MD)	Lightweight concrete	76800	826667.52	7521.20	9837.34	1762.03	2970.00	**13252570.80**	**29216910.16**	Buro Happold; Ramboll
		Metal deck	76800	826667.52					**1012418.39**	**2232002.30**	
		Mesh?									
		Studs?									

The Future Potential of Steel-Timber Hybrid Buildings:

Collecting & Processing EPDs

Timber:
73 EPDs





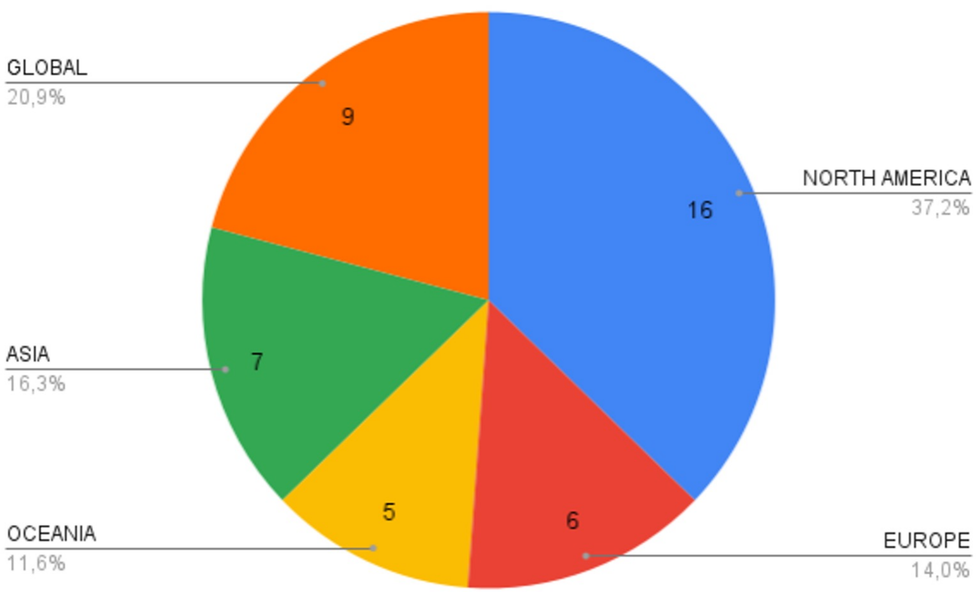
	CLT	GLT	SAWN	LVL
NORTH AMERICA	6	6	3	3
EUROPE	9	10	13	4
OCEANIA	2	1	6	-
GLOBAL	3	3	1	1

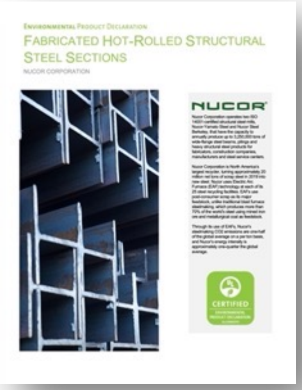
Researchers are still collecting and evaluating more EPDs

The Future Potential of Steel-Timber Hybrid Buildings:

Collecting & Processing EPDs

Steel:
43 EPDs



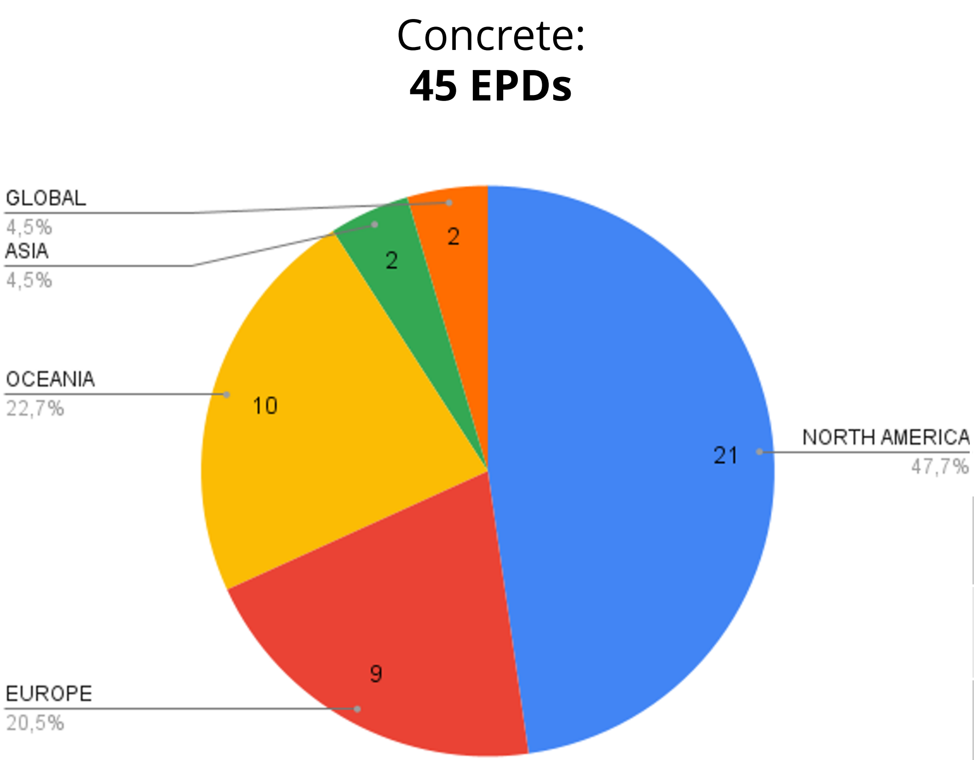


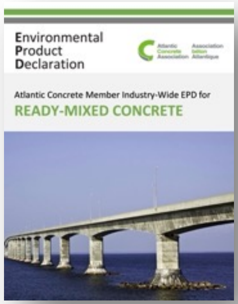
	HOT-ROLLED	HOLLOW	STRUCTURAL	WELDED
NORTH AMERICA	3	6	7	-
EUROPE	1	1	4	-
OCEANIA	3	-	-	2
ASIA	-	2	5	-
GLOBAL	5	-	4	-

Researchers are still collecting and evaluating more EPDs

The Future Potential of Steel-Timber Hybrid Buildings:

Collecting & Processing EPDs





	READY-MIX	REBARS	STEEL DECKS
NORTH AMERICA	9	11	1
EUROPE	4	4	1
OCEANIA	6	4	-
ASIA	1	-	1
GLOBAL	-	1	1

Researchers are still collecting and evaluating more EPDs

Featured Event:

Reframed: The Future of Cities in Wood

Reframed: The Future of Cities in Wood

Lecture Series

REFRAMED AND RECOVERED: A CONVERSATION WITH THE CURATORS

– PROGRAMS & EVENTS – REFRAMED AND RECOVERED: A CONVERSATION WITH THE...

TALKING TIMBER: WILL CHICAGO EMBRACE WOODEN HIGH-RISES?

– PROGRAMS & EVENTS – TALKING TIMBER: WILL CHICAGO EMBRACE WOODEN HIGH-RISES?

TALKING TIMBER: DESIGNING FUTURE CITIES IN WOOD

– PROGRAMS & EVENTS – TALKING TIMBER: DESIGNING FUTURE CITIES IN WOOD

PROGRAM ★

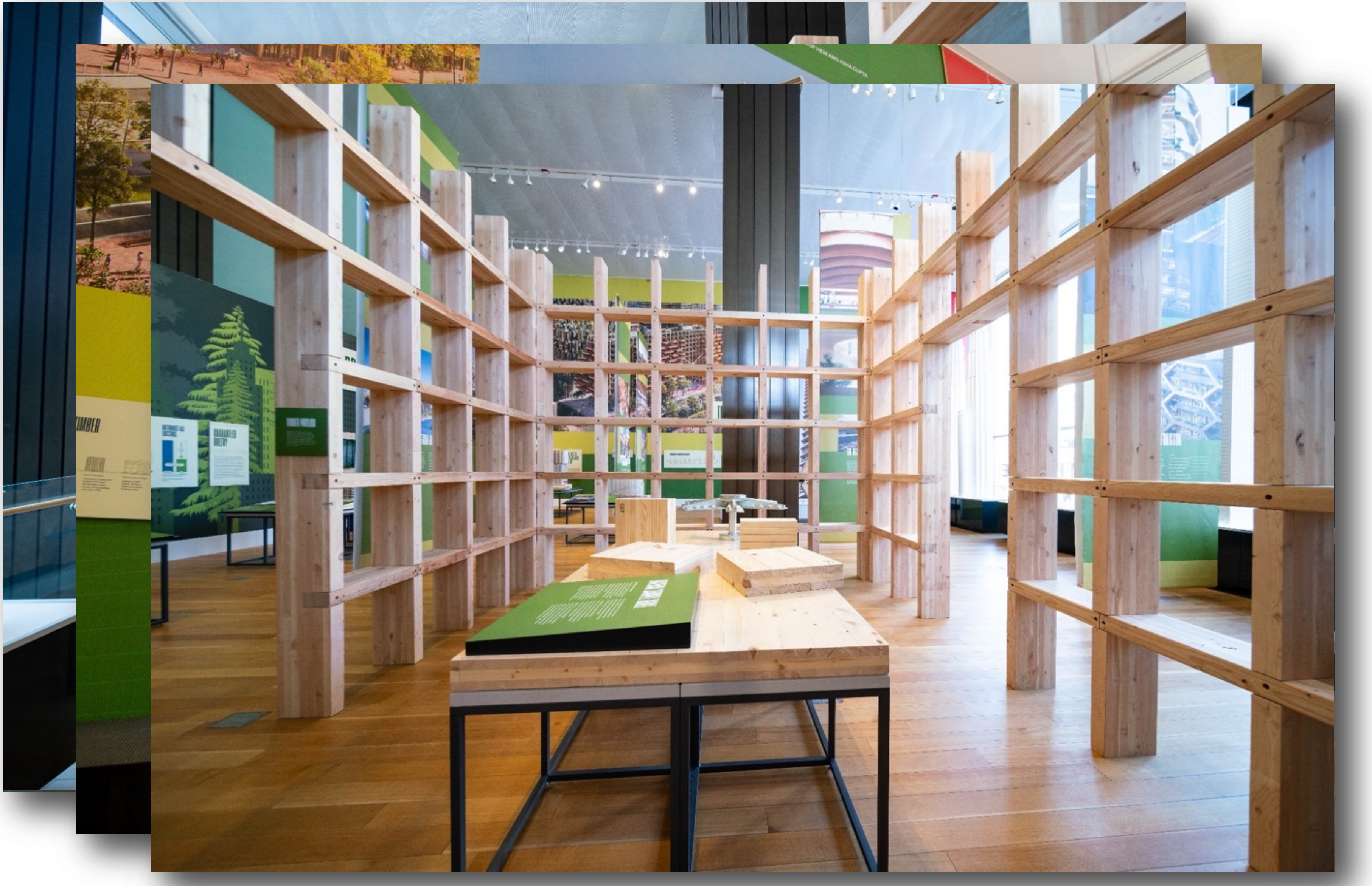
Join us in picturing a future of cities cast in wood. Our panel of international architects and researchers will unveil transformative development plans, skyscrapers, and cutting-edge innovations harnessing mass timber for sustainable growth.

DATE	September 19, 2023
TIME	6:00 pm
PRICE	Free, RSVP
MEET	Chicago Architecture Center Gand Lecture Hall and Zoom Virtual Event

REGISTER

Reframed: The Future of Cities in Wood

Skyscraper Gallery Exhibition



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