BUILDINGENERGY BOSTON

AIA Provider: Northeast Sustainable Energy Association

Provider Number: G338

COMBATING CLIMATE CHANGE WITH TIMBER CONSTRUCTION

Course Number BE1614

Whit Iglehart Partner, Tai Soo Kim Partners, LLC
Yugon Kim Director, Tai Soo Kim Partners, LLC, IKD, LLC,
Jean-Marc Dubois Director, Business Development at Nordic Structures
Dr. Peggi Clouston Associate Professor at University of Massachusetts

Session Curator: Brice Hereford

Course Date: March 9, 2016

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Tai Soo Kim Partners Architects

ikd

NORDIC
STRUCTURES

UNIVERSITY OF MASSACHUSETTS AMHERST 1863

UMASS
AMHERST

BCT
Building and
Construction
Technology
Program
bct.eco.umass.edu

COURSE DESCRIPTION

With its smaller carbon footprint, timber construction should be considered alongside steel and concrete to build both low and mid-rise projects. This session will introduce innovations in timber technology, and through case studies demonstrate the wide range of benefits including environmental benefits. With buildings in the U. S. accounting for 38% of all carbon emissions and with population growth on the rise, we must reconsider how we construct our buildings. Climate change can be combated in two ways –by reducing carbon emissions and by removing carbon from the atmosphere – and timber is unique in that it is the only building material that can do both. Recent innovations in timber technology is paving the way for timber once again to become integral to the fabric of cities, at this pivotal moment in time.

LEARNING OBJECTIVES

At the end of the this course, participants will be able to:

1. Advance sustainability by advocating for the use of timber construction.
2. Analyze broad benefits of timber over traditional steel and concrete construction methods.
3. Dispel common misconceptions about timber construction.
4. Discuss how timber construction fits in the construction industry and regulatory context.

COMBATING CLIMATE CHANGE WITH TIMBER CONSTRUCTION

BUILDINGENERGY BOSTON







URBAN TIMBER EXHIBITION

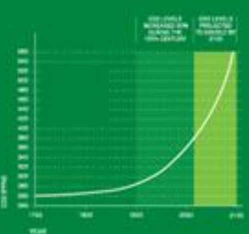
BOSTON SOCIETY OF ARCHITECTS

WHY BUILD WITH TIMBER?

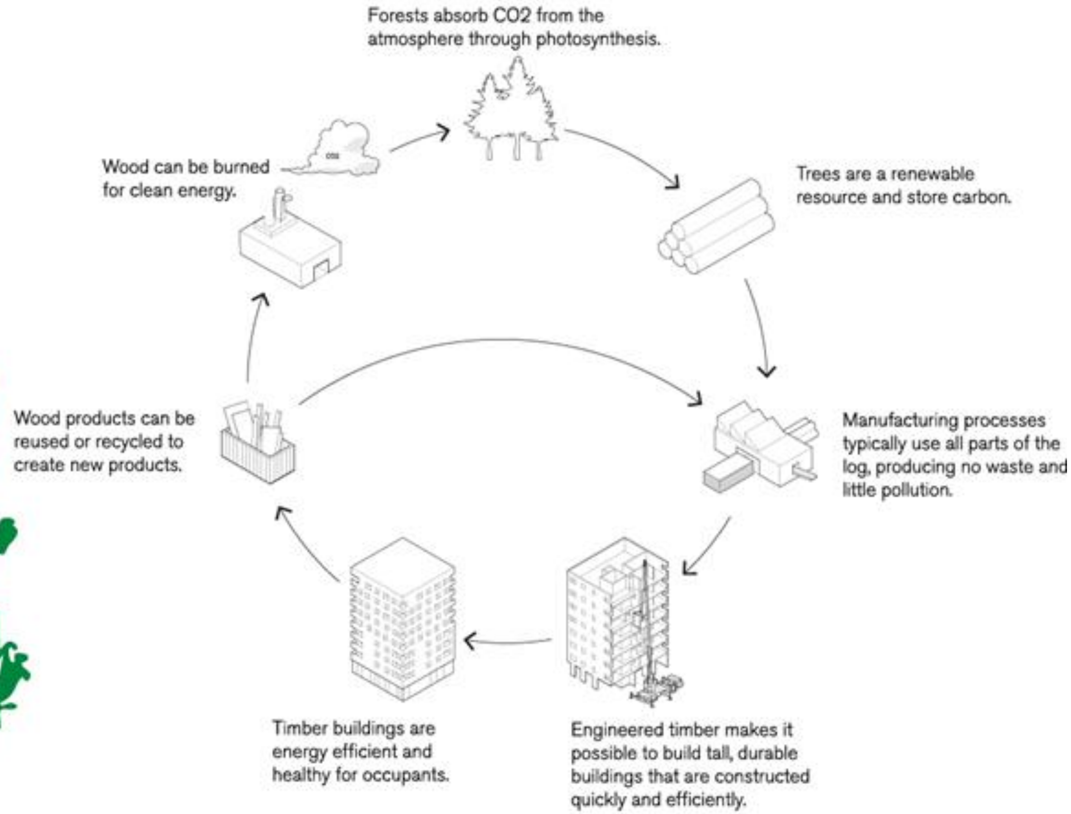
CLIMATE CHANGE

NEGATIVE CARBON FOOTPRINT

INCREASING CONCENTRATION OF C02 IN THE ATMOSPHERE



TIMBER PROVIDES BENEFITS AT EVERY STAGE OF ITS LIFE



WHY HARVEST WOOD ?

1. WOOD STORES CARBON

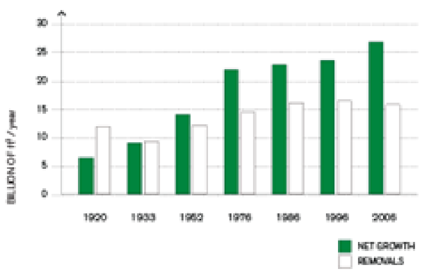
TREE'S NATURAL C02 CYCLE

1 Young trees absorb carbon rapidly
2 Mature trees absorb carbon slowly
3 Decaying trees and fires release carbon
4 Carbon is reabsorbed into new trees

HARVESTING TREES LOCKS C02 INTO THE TIMBER

2. WOOD IS RENEWABLE

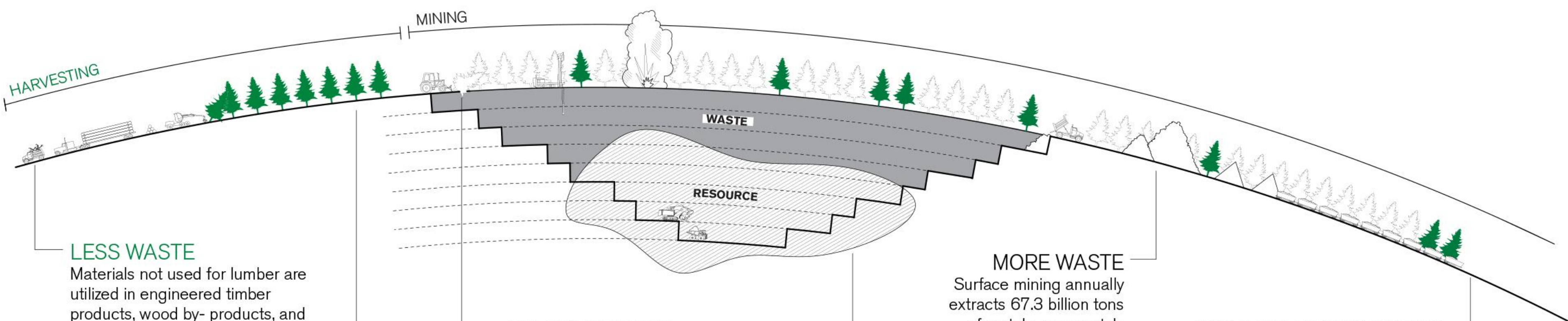
US TIMBER GROWTH AND REMOVALS
1920–2006



3. LOWER IMPACT

WHY HARVEST WOOD ?

3. LOWER IMPACT



LESS WASTE
Materials not used for lumber are utilized in engineered timber products, wood by- products, and biofuels.

GROWTH EXCEEDS PROJECTED HARVEST
Due to sustainable forest management certification systems, today's forest growth exceeds harvest by 40%. The average standing volume of wood in the US is 50% greater than it was in 1952.

DEFORESTATION
Mining results in deforestation. The damage mining causes to water supplies, habitats and air quality is long lasting, often permanent. For example, in Montana, replanting projects had only a 20–30% a success rate.

MORE WASTE
Surface mining annually extracts 67.3 billion tons of metals, non- metals and coal. Of that, 30 billion tons is waste.

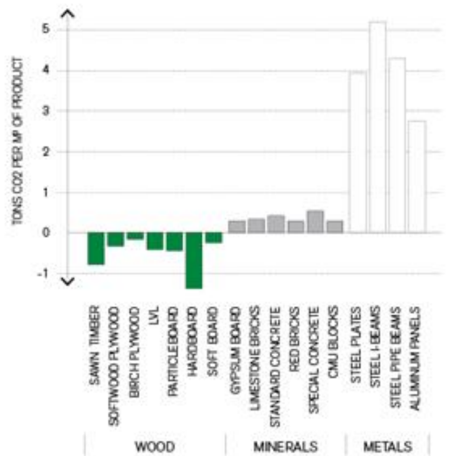
THE EARTH'S SURFACE IS NOT RENEWABLE
While the Earth's mineral reserves are currently sufficient, extraction is becoming increasingly difficult. As easily extracted ores are being depleted, more energy is needed to maintain production rates. Mining is becoming economically unfeasible.

MORE INFRASTRUCTURE
Cost of transportation- roads, highways, pipelines, airports, railroads, waterways and harbors—is generally greater than 50% of a mine's total operating cost.

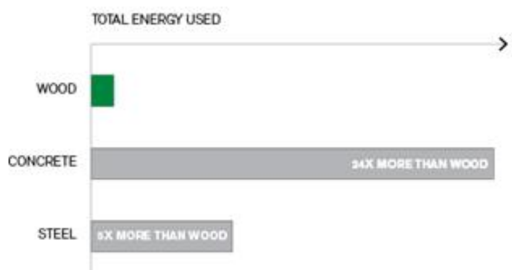
WHY MANUFACTURE TIMBER PRODUCTS?

1. TIMBER PRODUCTION CAUSES LESS POLLUTION

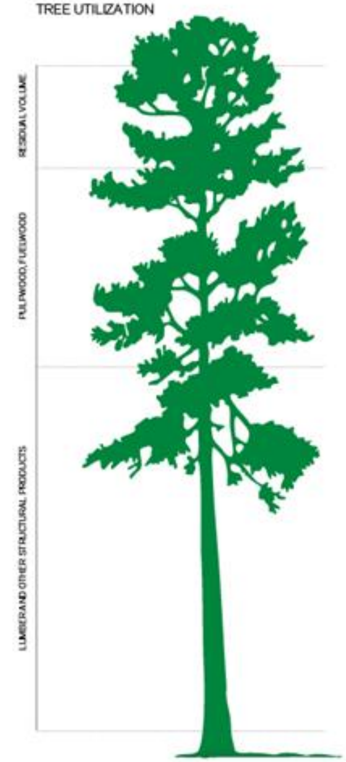
NET CO2 EMISSIONS OF BUILDING MATERIALS



ENERGY USED TO PRODUCE ONE TON OF MATERIAL



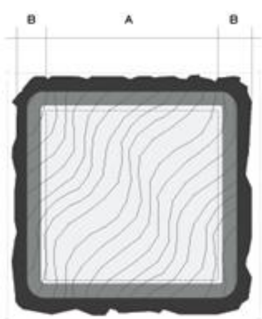
2. NOTHING GOES TO WASTE



3. ENGINEERED WOOD MAXIMIZES RESOURCES

WHY BUILD WITH TIMBER?
FIRE RESISTANCE

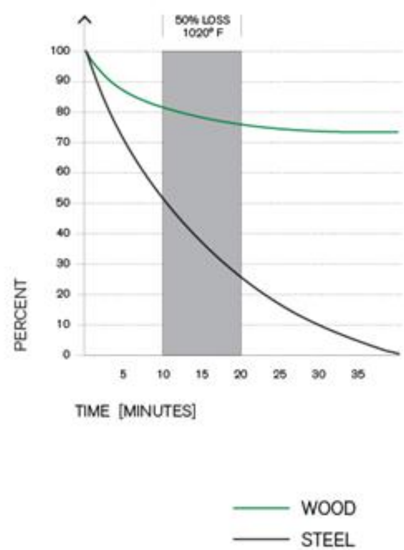
FIRE RESISTANT TIMBER BEAM:
CHARRING DIAGRAM

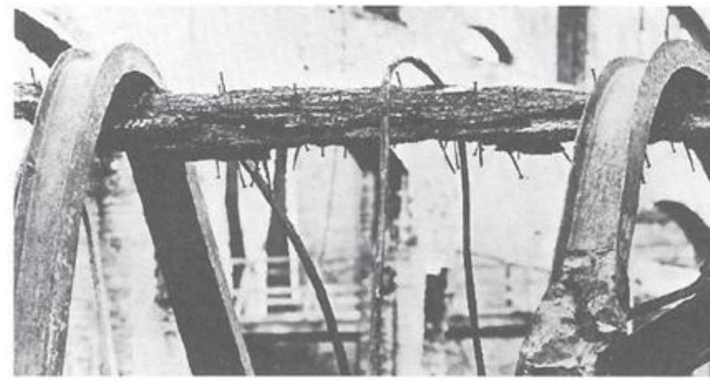


A RESIDUAL SECTION - STRUCTURAL CAPACITY RETAINED

B SACRIFICIAL (CHAR) LAYER - NO STRUCTURAL CAPACITY RETAINED

WOOD VS. STEEL:
LOSS OF STRENGTH IN FIRE



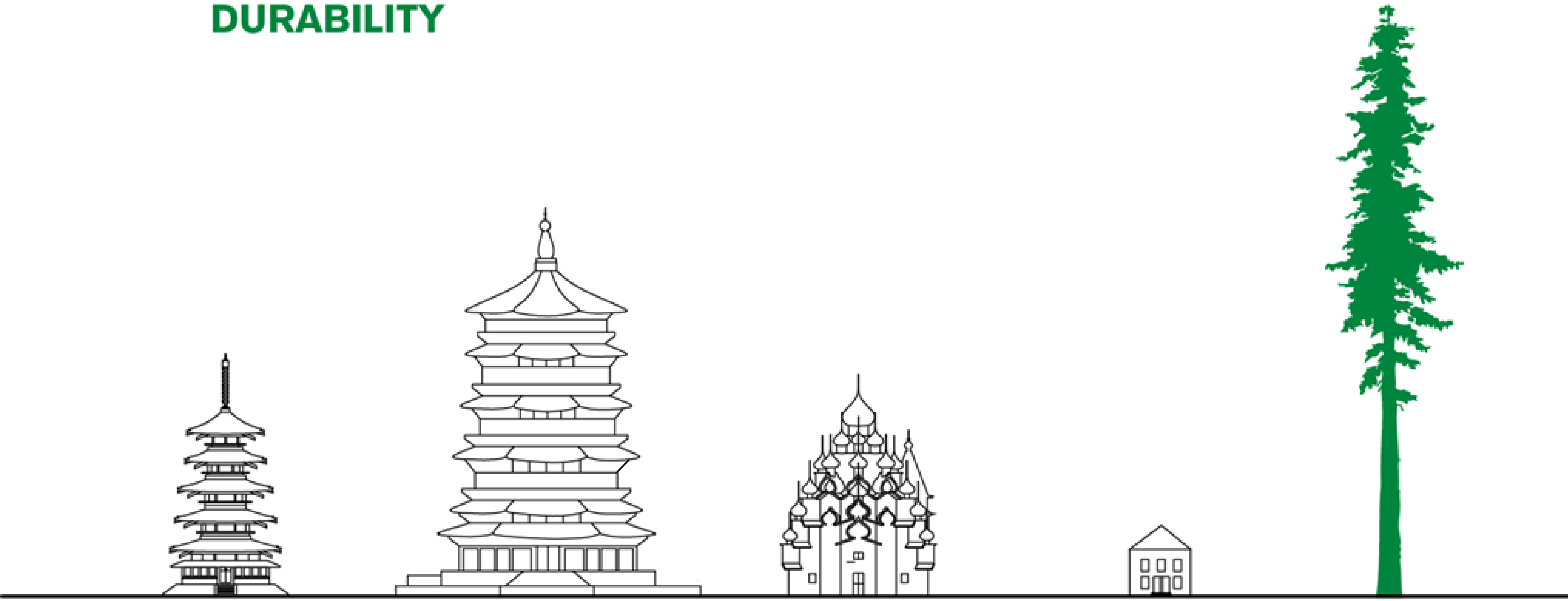


AFTER FIRE SCENE
WOOD BEAM SUPPORT TWISTED STEEL BEAMS

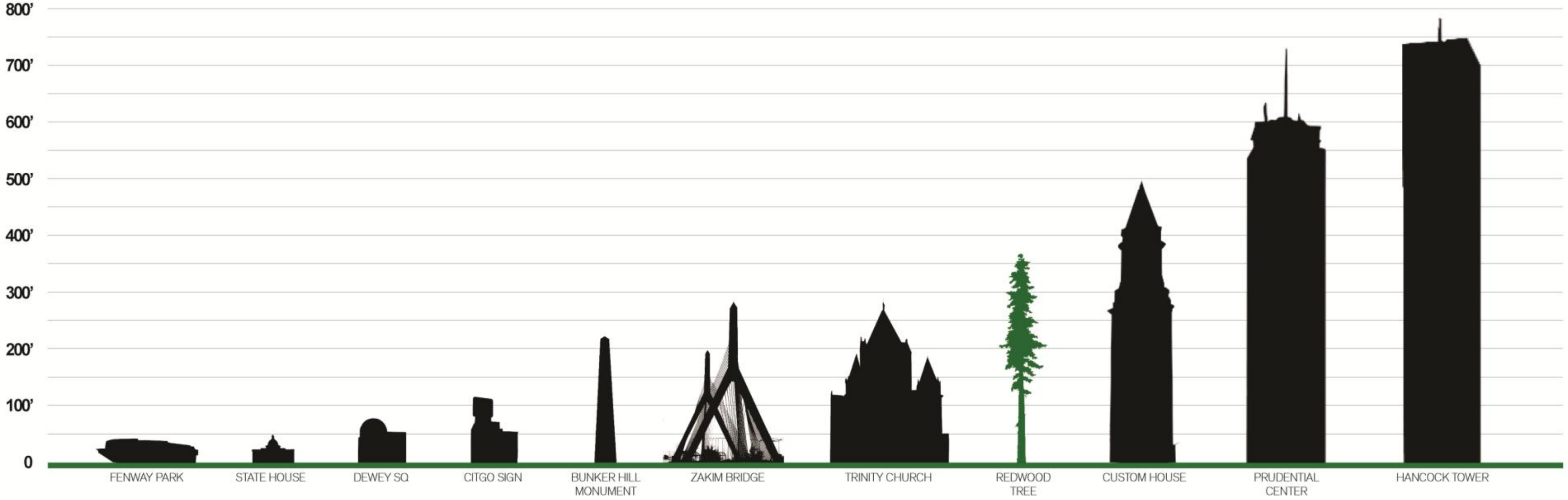
AFTER FOREST FIRE
LARGE TREES REMAIN

WHY BUILD WITH TIMBER?

DURABILITY



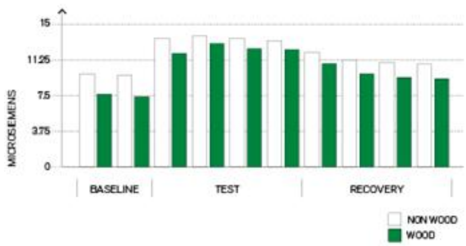
WHY BUILD WITH TIMBER?
DURABILITY



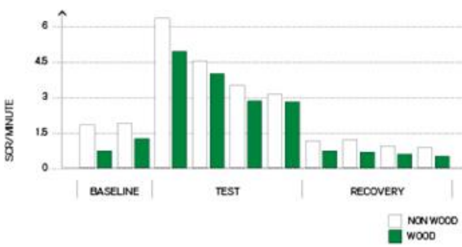
WHY LIVE WITH TIMBER?

1. HAPPINESS

SKIN CONDUCTANCE LEVEL (SCL)



SKIN CONDUCTANCE
RESPONSES PER MINUTE (SCR)



2. LOWER STRESS

TIMBER TYPES

HEAVY TIMBER

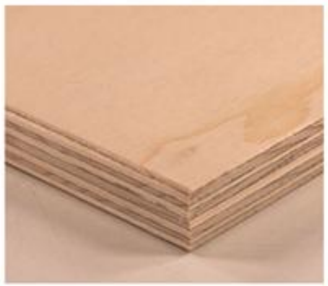
320 MILLION YEARS AGO

PARALLEL STRAND TIMBER

1959

PLYWOOD

1865



LAMINATED STRAND LUMBER

1959

GLUE LAMINATED TIMBER

1896

ORIENTED STRAND BOARD

1978

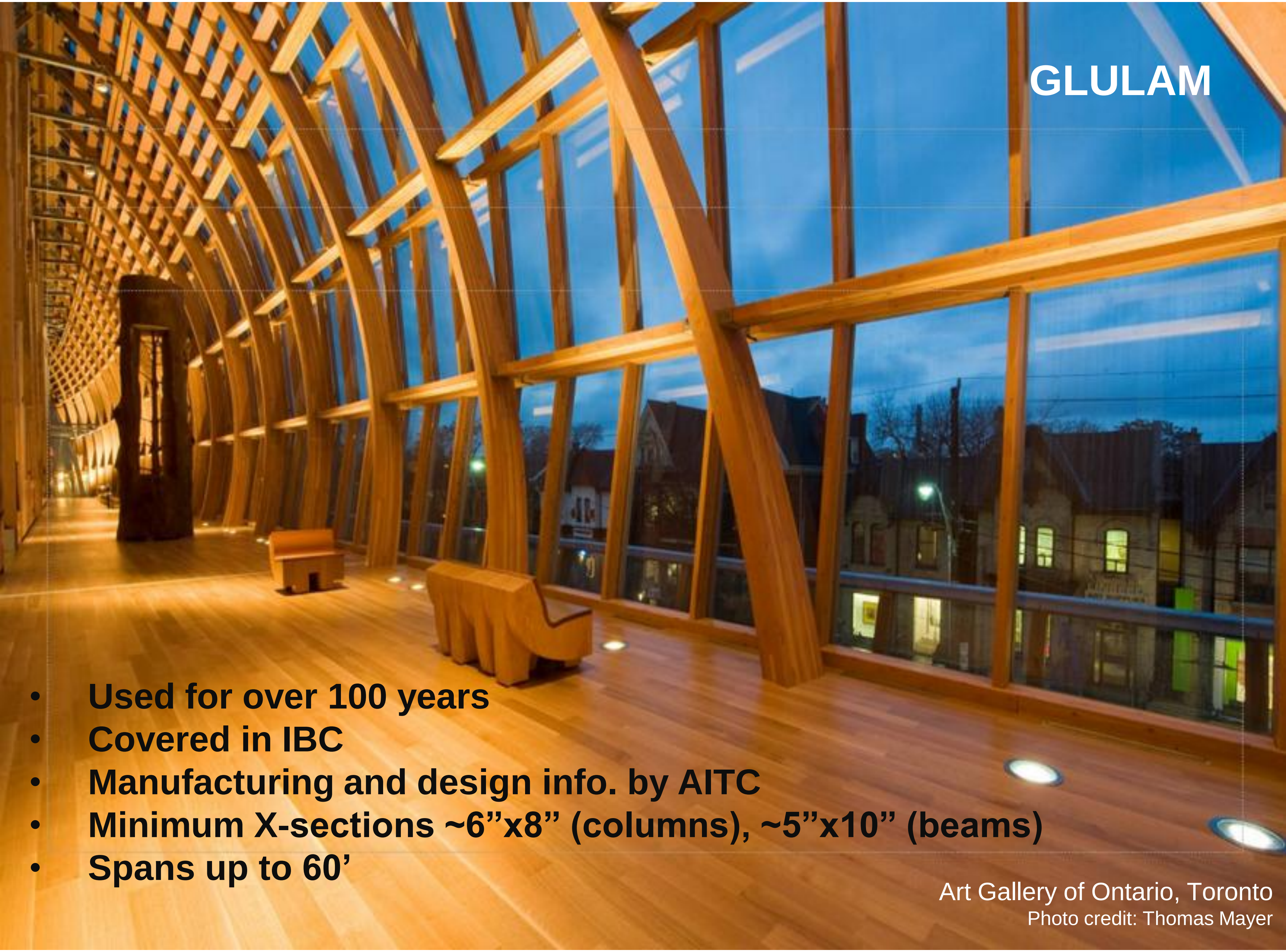
LAMINATED VENEER LUMBER

1959

CROSS LAMINATED TIMBER

1990

GLULAM

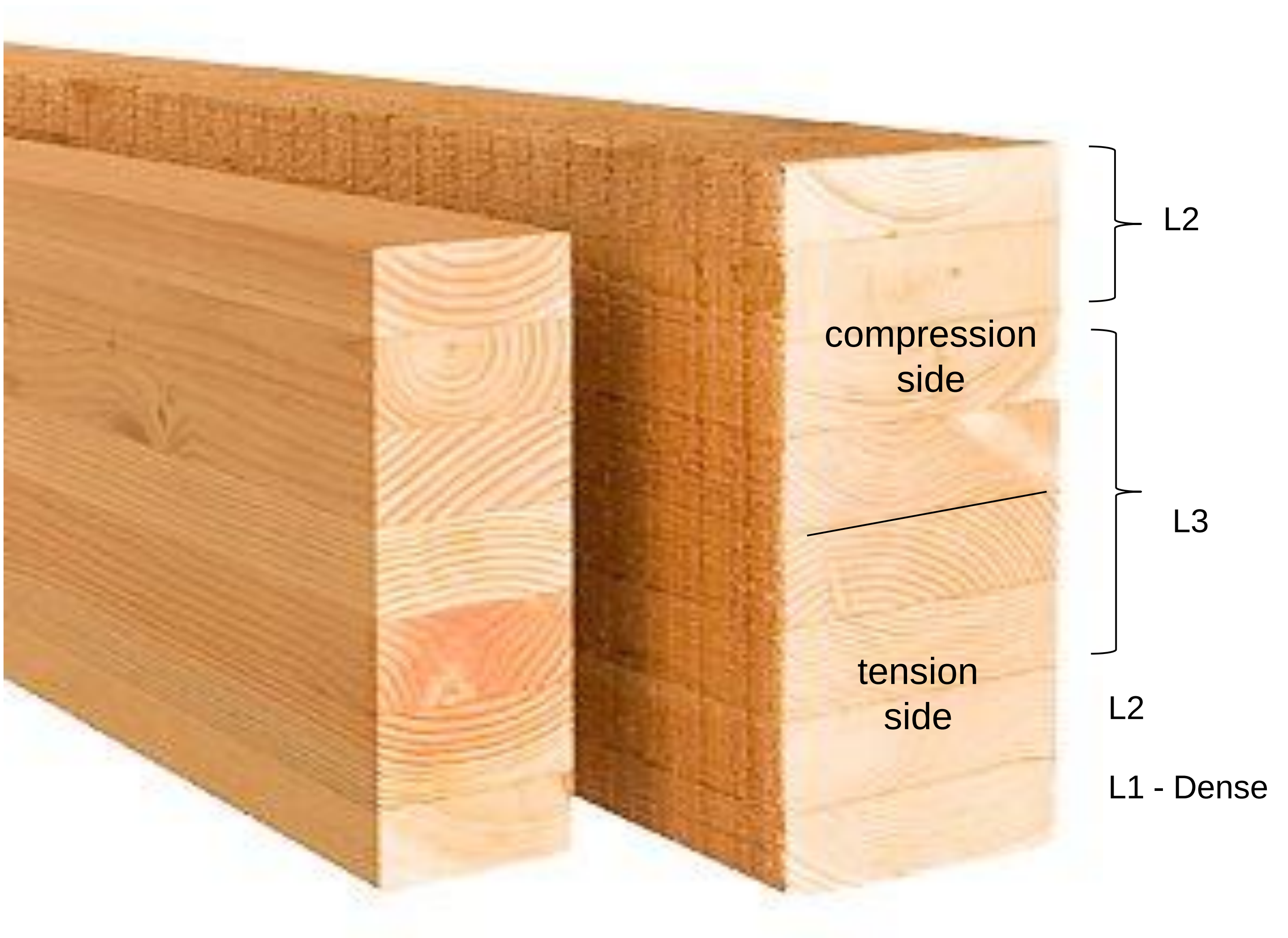


- Used for over 100 years
- Covered in IBC
- Manufacturing and design info. by AITC
- Minimum X-sections ~6”x8” (columns), ~5”x10” (beams)
- Spans up to 60’

Art Gallery of Ontario, Toronto
Photo credit: Thomas Mayer

THE SECRET BEHIND GLULAM STRENGTH

- Defects are dispersed
- Layup is engineered



CROSS LAMINATED TIMBER

WOOD STRUCTURE

TREE TRUNK

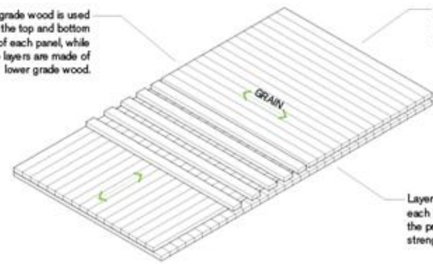
TREE CELL (250X)

The tree trunk's long tubular cells, similar to drinking straws, give wood its strength and stability.

Wood is the strongest and most stable in the direction of the grain.

Wood is weaker and more prone to expansion and shrinkage in the cross-grain direction.

MAKING CROSS LAMINATED TIMBER



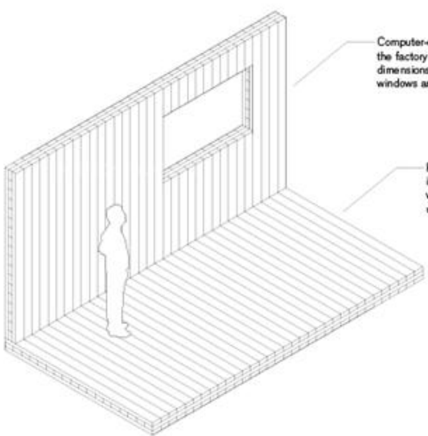
WOOD PANEL LAYOUT

High grade wood is used for the top and bottom layers of each panel, while the core layers are made of lower grade wood.

CLT technology utilizes small low grade logs that would otherwise go to waste.

Layers of boards are glued together with each layer's grain laid perpendicular to the previous ones to provide maximum strength and stability.

BUILDING WITH CLT ELEMENTS

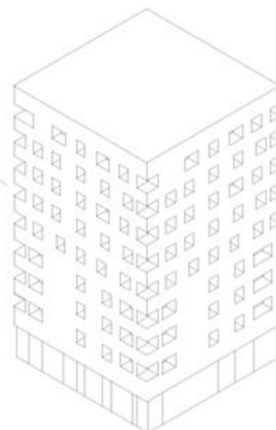


CLT ASSEMBLY

Computer-controlled machinery in the factory trims the panels to exact dimensions, and cuts openings for windows and other installations.

Panels are prefabricated off-site in a factory and can be used for various applications, speeding up construction time.

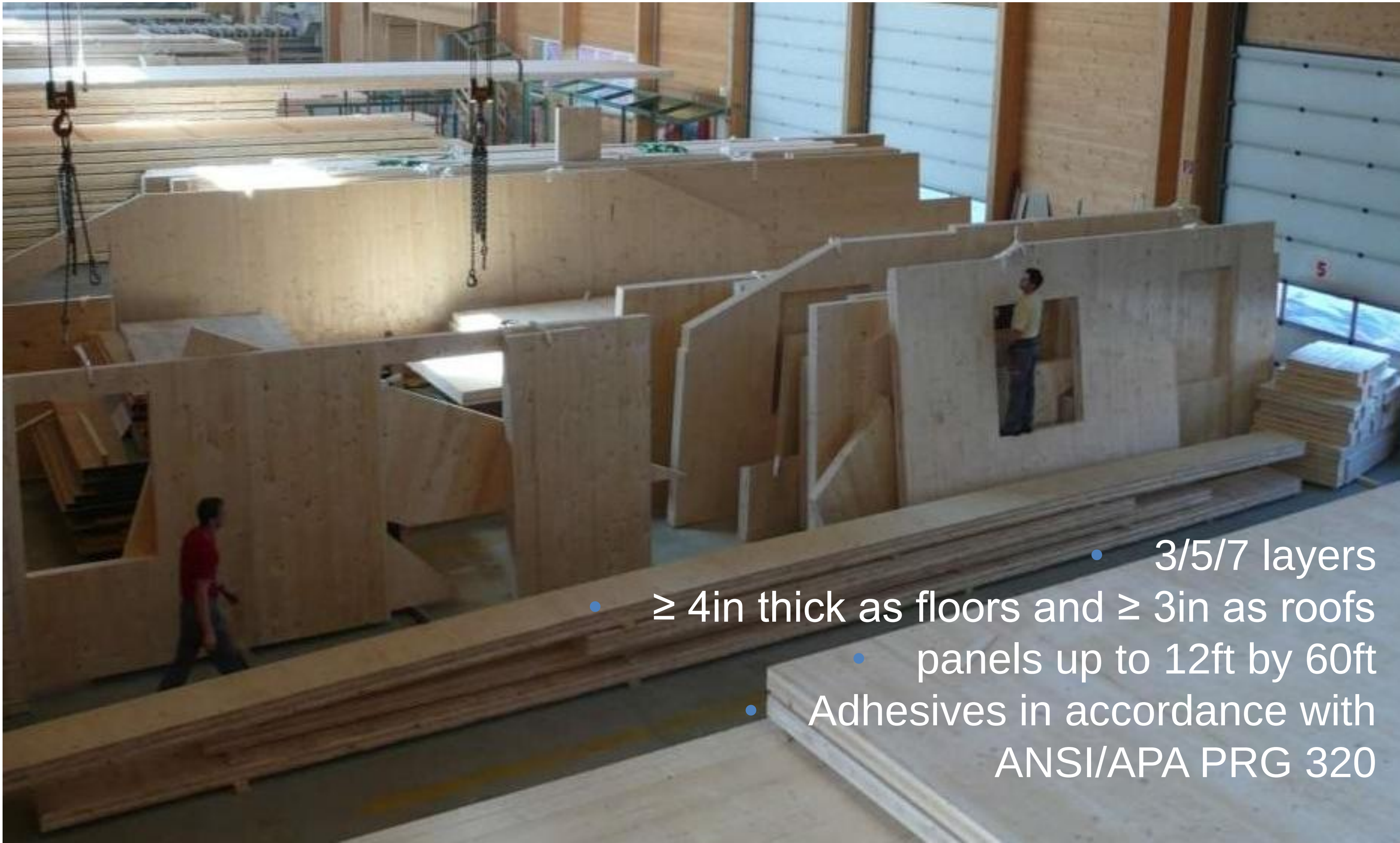
BUILDING WITH CLT



CLT MID-RISE TOWER

Like heavy timber construction and light frame balloon framing that came before it, CLT technology marks a milestone in timber construction allowing buildings to be erected faster than ever.

CROSS LAMINATED TIMBER



- 3/5/7 layers
- ≥ 4in thick as floors and ≥ 3in as roofs
- panels up to 12ft by 60ft
- Adhesives in accordance with ANSI/APA PRG 320

CLT CODES AND STANDARDS

- *ANSI/APA PRG 320-2011:*
  Standard for Performance-Rated Cross Laminated Timber – APA

- *APA Product Reports® – APA*

- *CLT Handbook (www.masstimber.com)*

- *Case studies and design examples:*

  (http://www.woodworks.org/design-with-wood/building-systems-clt/)

- *Research:*
  - *10-30 stories: “The Case for Tall Wood Buildings”*

    (http://www.woodworks.org/wp-content/uploads/CWC-Tall-Walls2.pdf)

IS TIMBER CONSTRUCTION CODE COMPLIANT?

TIMBER CODE COMPLIANCE - IBC Height and Areas

- *IBC allows up to 65 ft height, 5 story as Type IV – HT (85 ft, 6 stories sprinklered)*

- *IBC 2015: CLT and SCL included (alongside glulam) as Type IV HT construction*

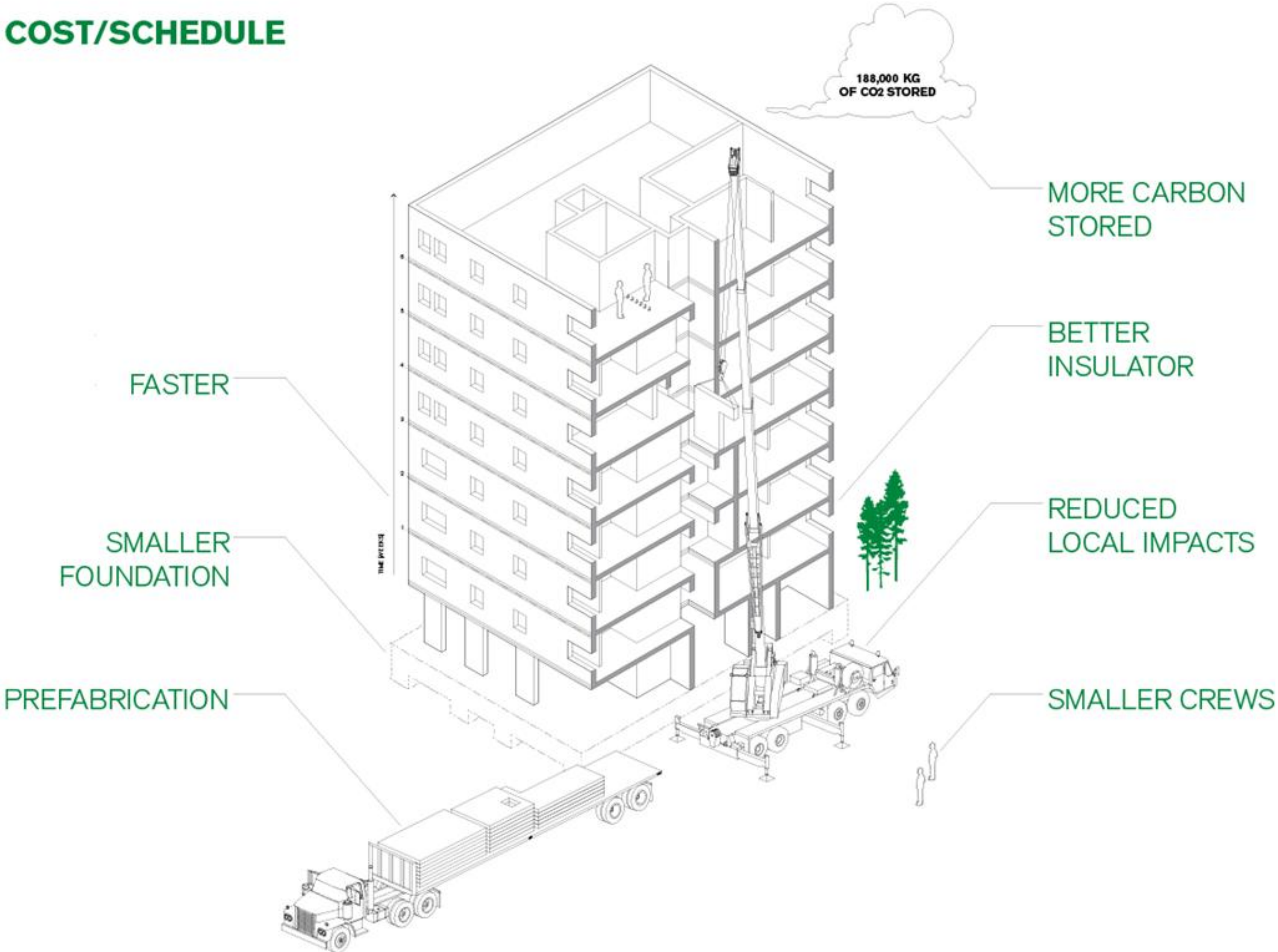
Appleton Mills c. 1870, Lowell MA
Photo credit: CWC Builders

TABLE 503 ALLOWABLE BUILDING HEIGHTS AND AREAS[a, b] Building height limitations shown in feet above grade plane. Story limitations shown as stories above grade plane. Building area lin building," per story

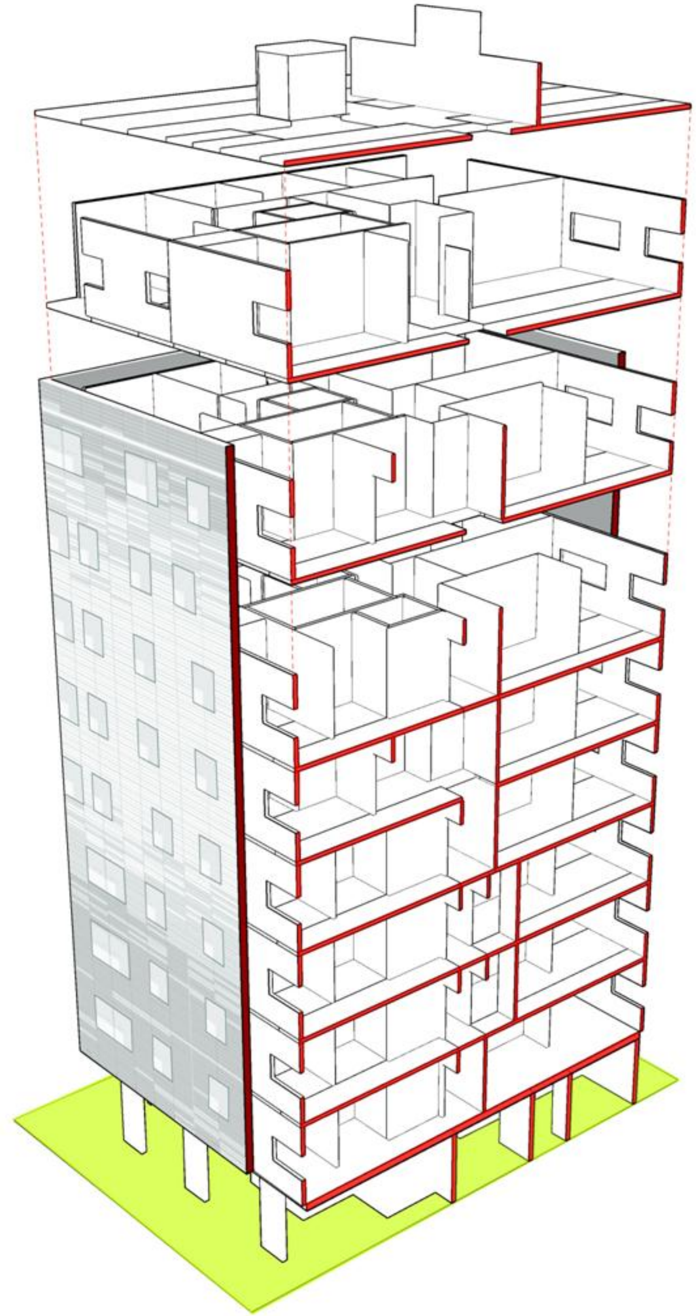
GROUP		TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
	HEIGHT (feet)	UL	160	65	55	65	55	65	50	40
		STORIES(S) AREA (A)								
A-1	S A	UL UL	5 UL	3 15,500	2 8,500	3 14,000	2 8,500	3 15,000	2 11,500	1 5,500
A-2	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-3	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-4	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-5	S A	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL
B	S A	UL UL	11 UL	5 37,500	3 23,000	5 28,500	3 19,000	5 36,000	3 18,000	2 9,000
E	S A	UL UL	5 UL	3 26,500	2 14,500	3 23,500	2 14,500	3 25,500	1 18,500	1 9,500
F-1	S A	UL UL	11 UL	4 25,000	2 15,500	3 19,000	2 12,000	4 33,500	2 14,000	1 8,500
F-2	S A	UL UL	11 UL	5 37,500	3 23,000	4 28,500	3 18,000	5 50,500	3 21,000	2 13,000

WHY CONSTRUCT WITH TIMBER?

COST/SCHEDULE



MURRAY GROVE
LONDON, ENGLAND
9 STORY RESIDENTIAL TOWER

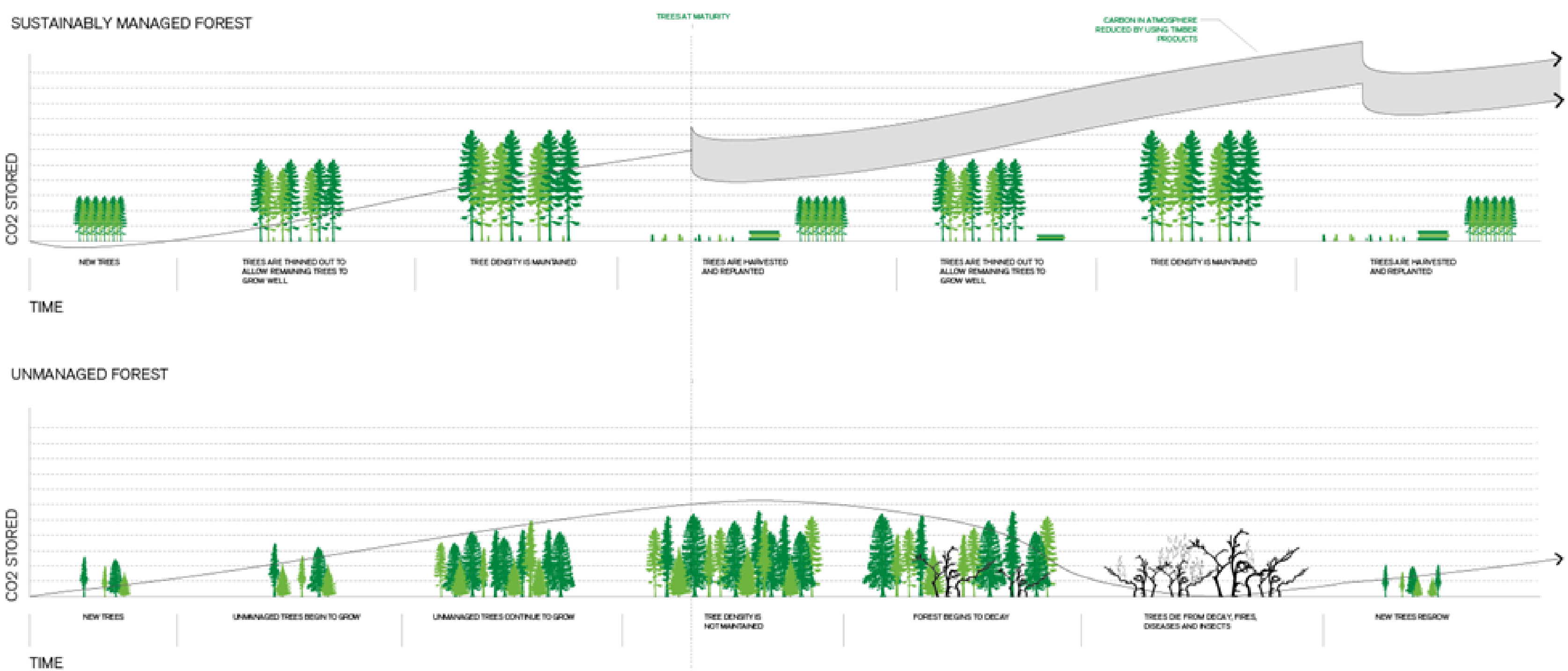


WILL INCREASING TIMBER USE LEAD TO DEFORESTATION?

WILL INCREASING TIMBER USE LEAD TO DEFORESTATION?

1. **MANAGED FORESTS ARE HEALTHY FORESTS**
2. **HIGHER DEMAND FOR TIMBER MEANS MORE TREES**

PLANTED FORESTS OCCUPY ONLY 7% OF THE WORLD'S FOREST AREA BUT PROVIDE 41% OF THE WOOD GLOBALLY HARVESTED



TIMBER STRUCTURE: The Design Building at UMass, Amherst

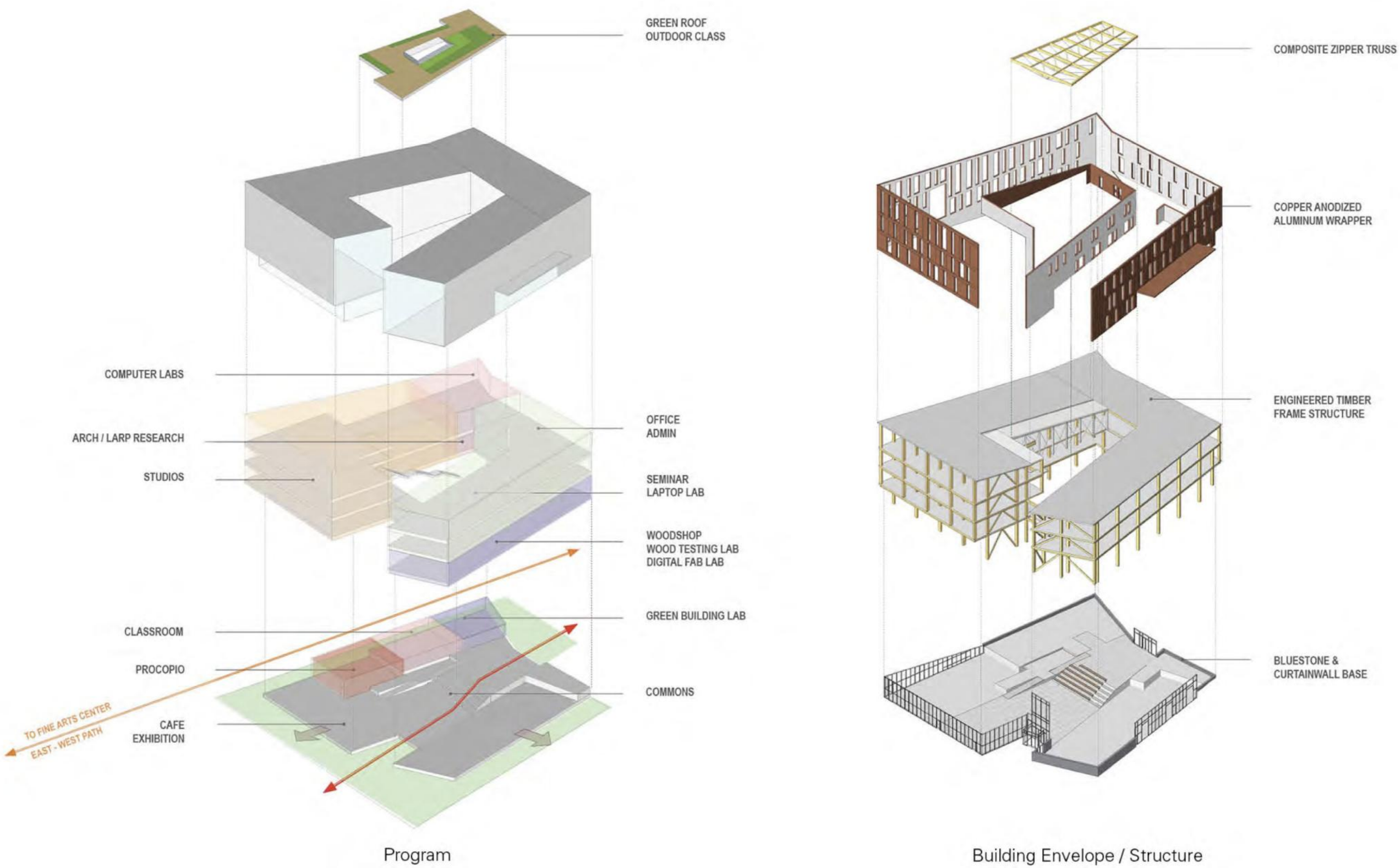
View from North Pleasant Street
Image credit : Leers Weinzapfel Associates

DEMONSTRATION BUILDING

MAIN ATRIUM AND EXHIBIT SPACE

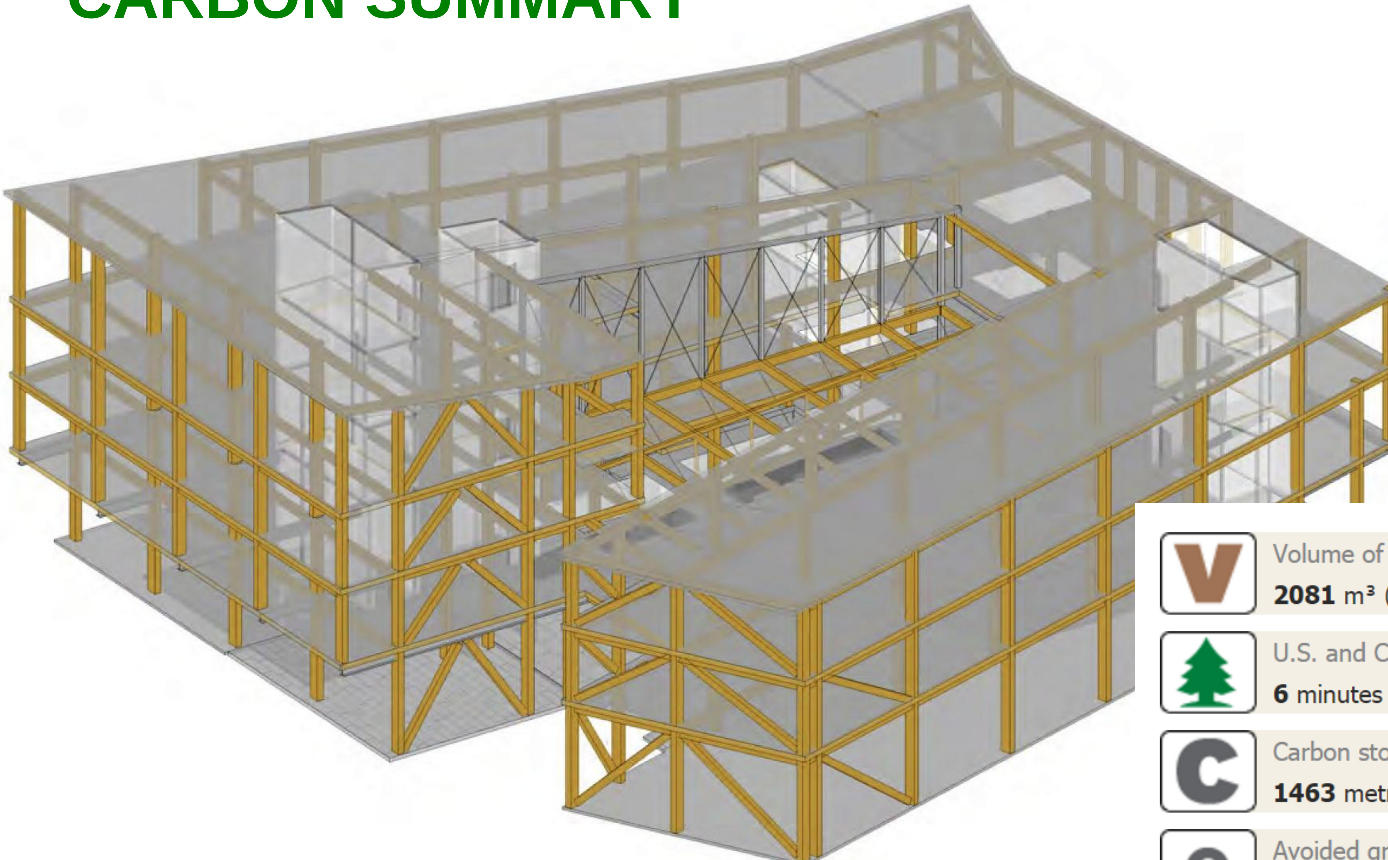
Image credit : Leers Weinzapfel Associates

BUILDING LAYOUT



Exploded Axonometrics

CARBON SUMMARY



Volume of wood products used (m³):
2081 m³ (73482 ft³) of lumber and sheathing

U.S. and Canadians forests grow this much wood in:
6 minutes

Carbon stored in the wood:
1463 metric tons of CO_2

Avoided greenhouse gas emissions:
1218 metric tons of CO_2

Total potential carbon benefit:
2681 metric tons of CO_2

Equivalent to:

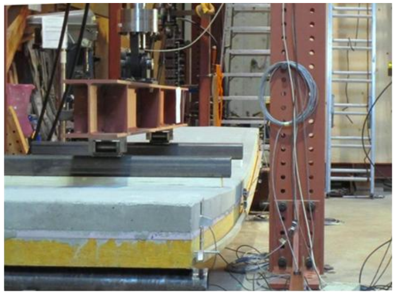
512 cars off the road for a year

Energy to operate a home for **228** years

LEADING-EDGE TIMBER TECHNOLOGY

Cross Laminated Timber

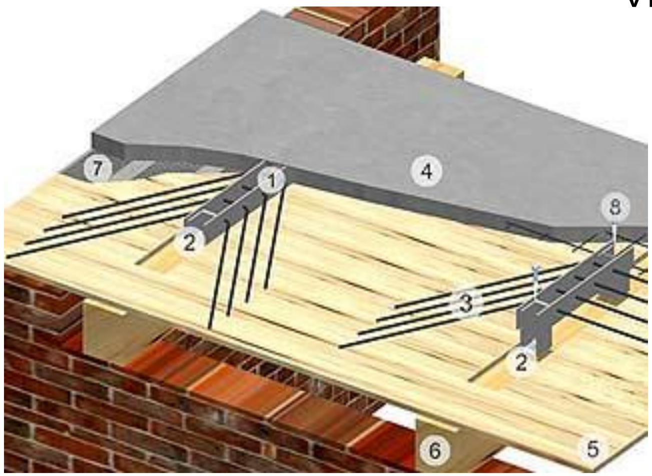
Glulam



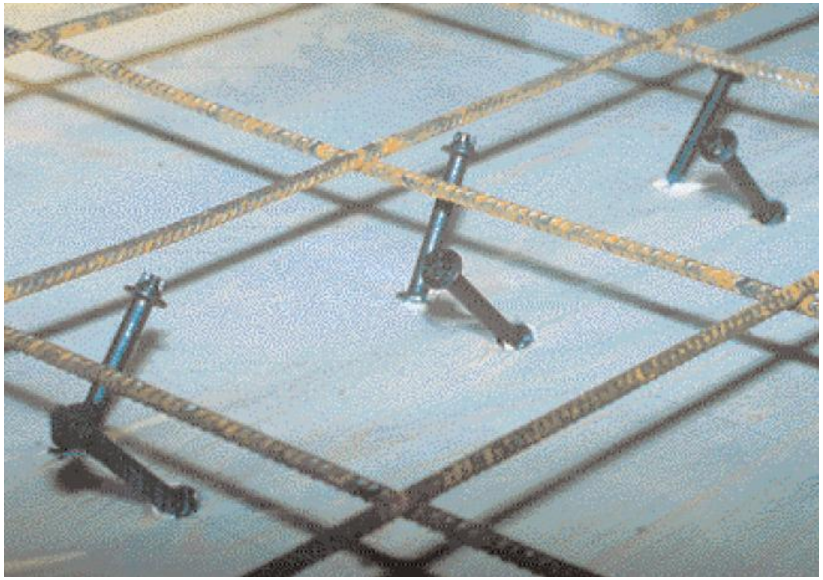
Wood Concrete Composites

WOOD CONCRETE COMPOSITE TECHNOLOGY

Bertsche connector

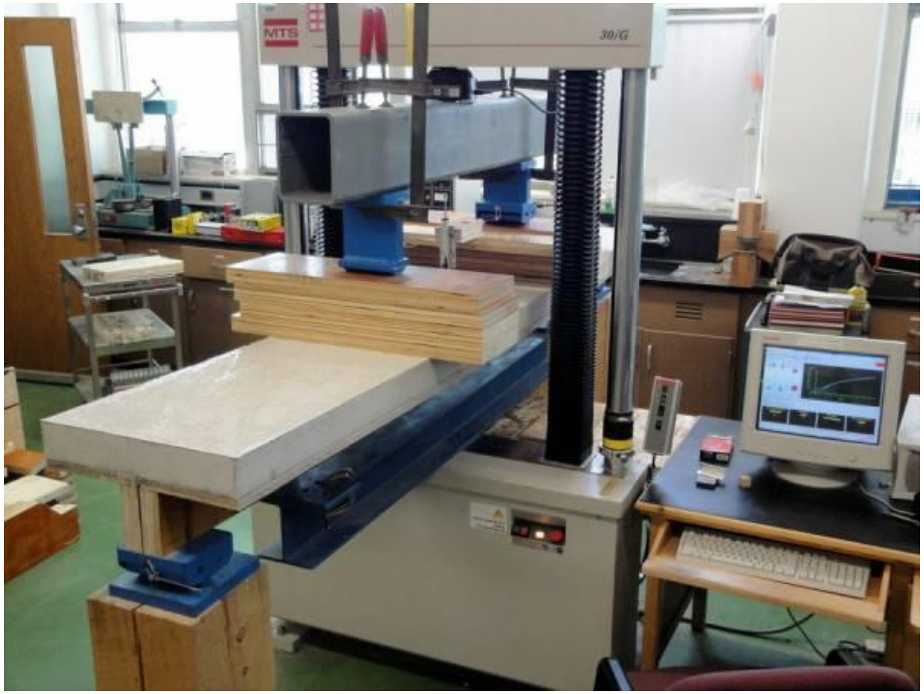


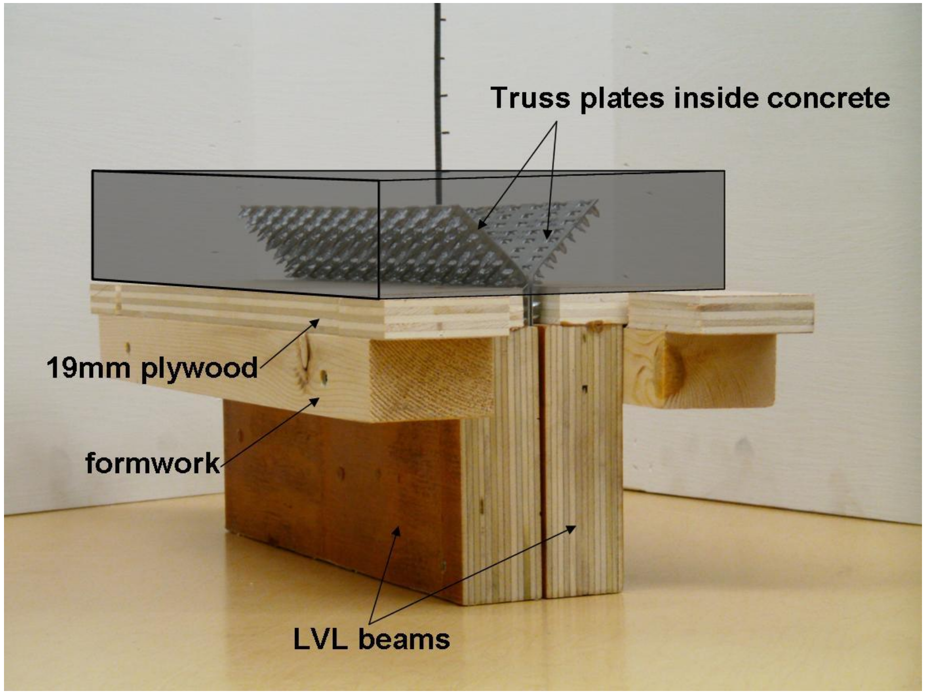
SFS Intec
VB Screws

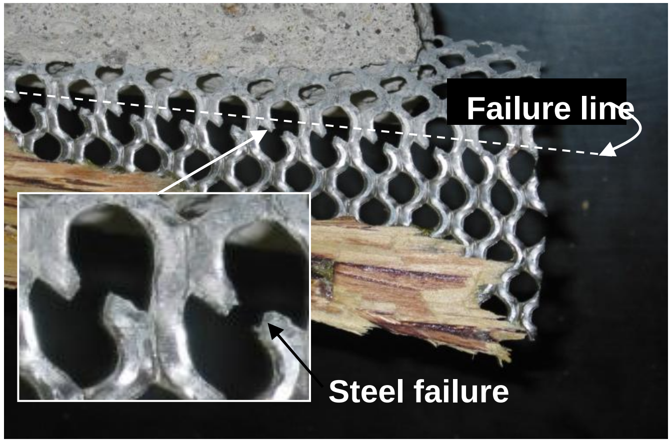


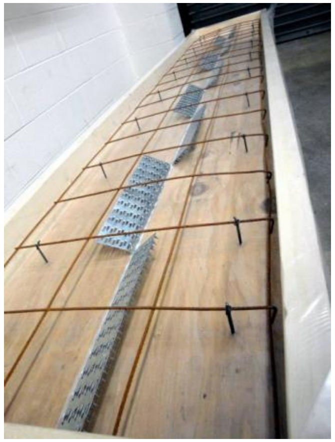
HBV system

WOOD CONCRETE COMPOSITES: UMASS RESEARCH

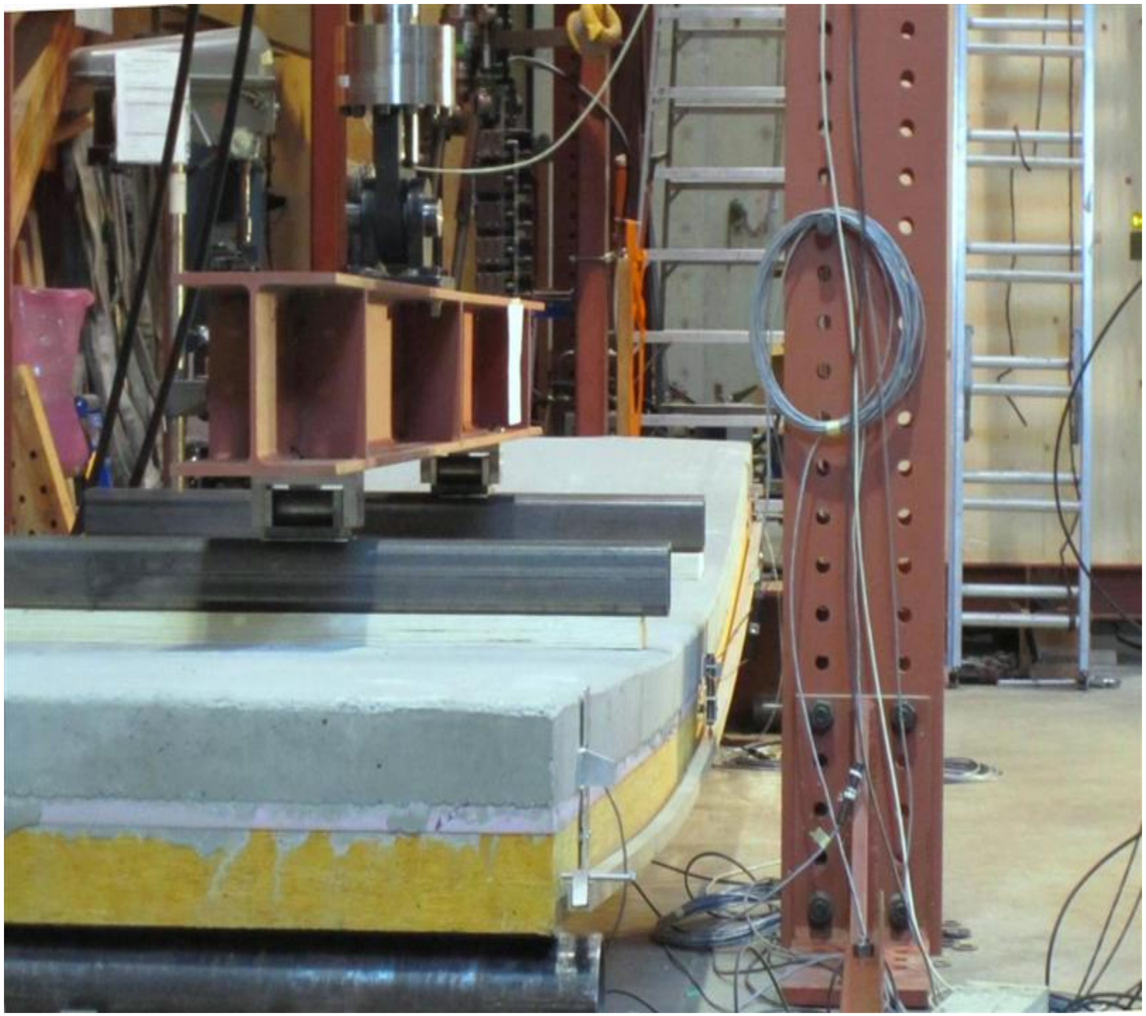


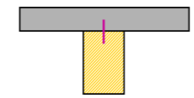






WOOD CONCRETE COMPOSITES: BENEFITS

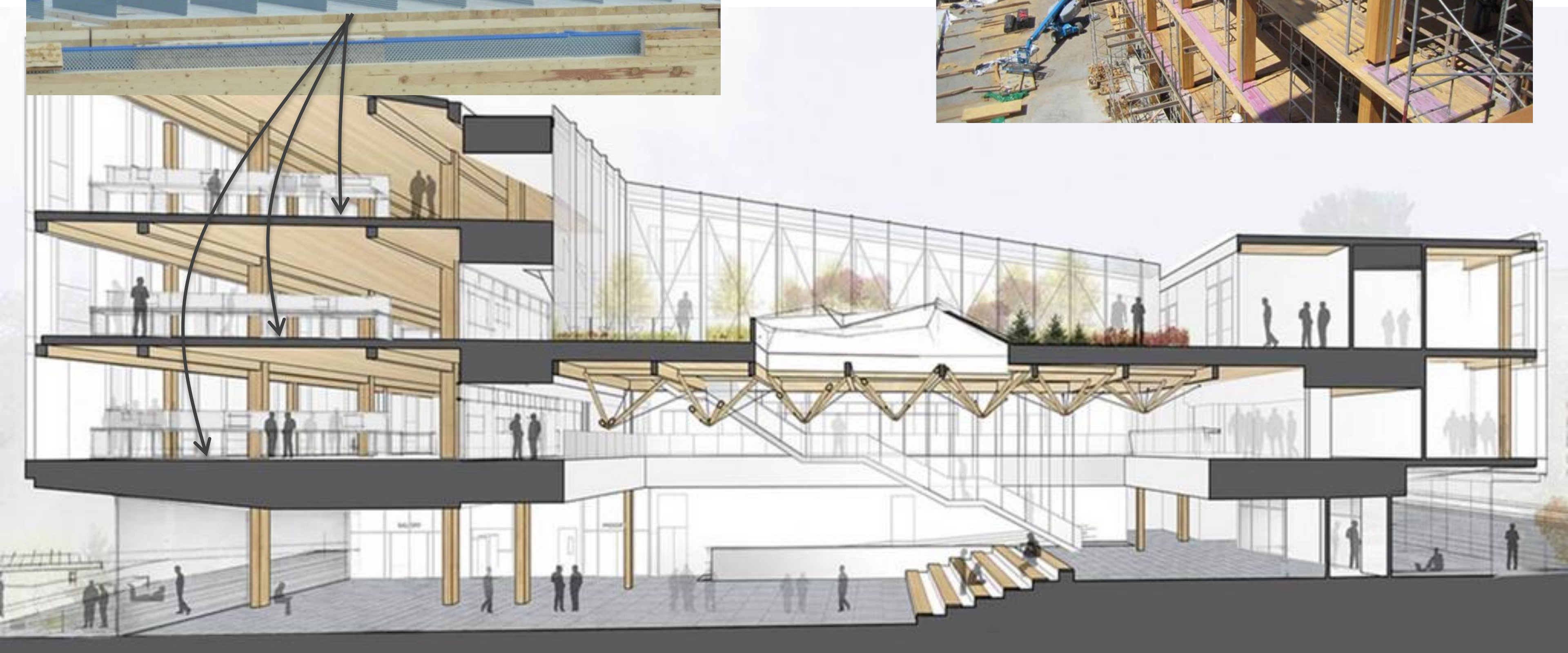


Wood	Wood-concrete composite	
		
→	Strength	Stiffness
	Increase up to **2** times	Increase up to **4** times

Publications

- **Clouston P**, Schreyer A. 2012. “Experimental Evaluation of Connector Systems for Wood Concrete Composite Floor systems in Mill Building Renovations.” International Journal of the Constructed Environment, Volume 2, Issue 1, pp.131-144.
- **Clouston P**, Schreyer A. 2008. “Design and Use of Wood-Concrete Composites”. ASCE Practice Periodical on Structural Design and Construction, 13(4), pp. 167-175
- **Clouston P**, Bathon L, Schreyer A. 2005. “Shear and Bending Performance of a Novel Wood-Concrete Composite System”. ASCE Journal of Structural Engineering. 131(9), pp.1404-1412
- **Clouston P**, Civjan S, Bathon L. 2004. “Experimental Behavior of a Continuous Metal Connector for a Wood-Concrete Composite System”. Forest Products Journal. 54(6) pp. 76-84

WOOD CONCRETE COMPOSITES: IMPLEMENTATION



TIGHT TOLERANCES:

GLULAM COLUMN INSTALLATION

CONNECTIONS

DESIGN BUILDING IN CONSTRUCTION: 24 HOURS

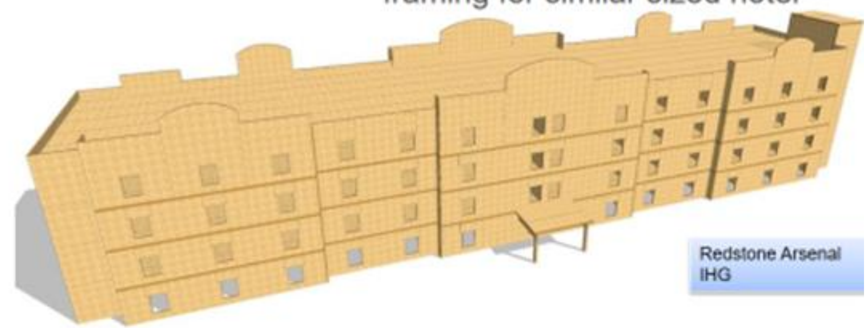
FSC COMMERCIAL BUILDING OF THE YEAR, 2010

FONDACTION OFFICE BUILDING
QUEBEC, CANADA

Client: PAL-US Army
Contractor: Lendlease
Project Cost: $17 M
Timber Cost: $2 M

- 75% faster production rate
- 43% fewer framing man hours
- 44% fewer framing workers
- 27% more energy efficient

Compared to conventional framing for similar sized hotel



IHG ARMY HOTEL
ALABAMA

100 METER LONG SPAN STRUCTURE
OF PINE BEETLE KILL WOOD

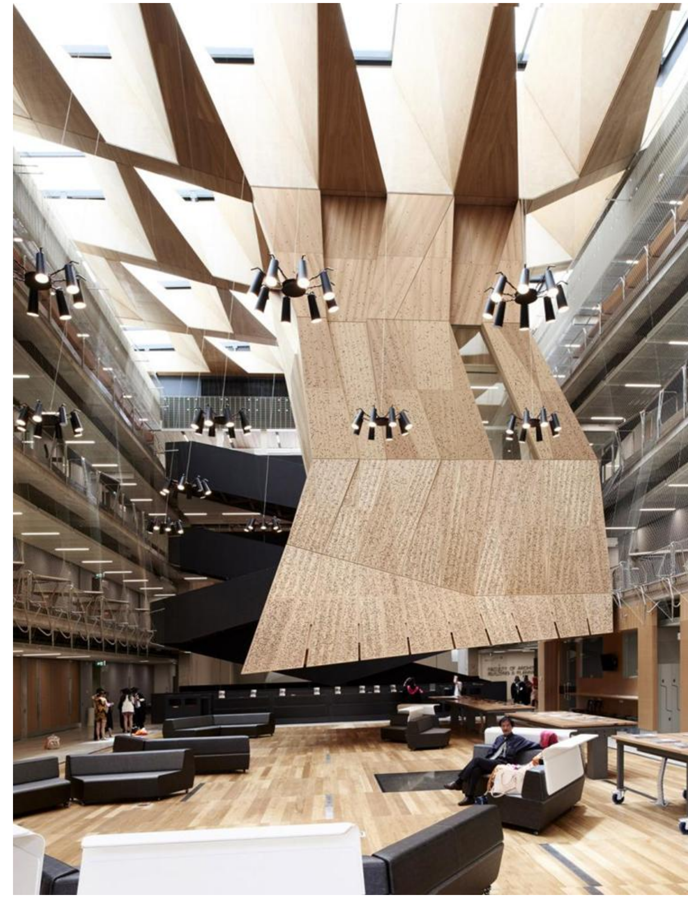
RICHMOND OLYMPIC OVAL
Richmond, BC, Canada

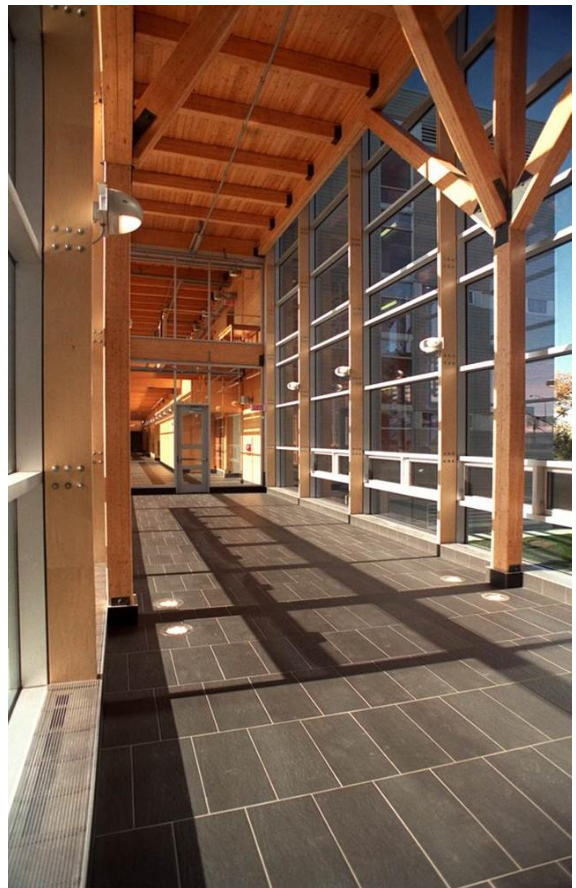

WINNER; PALME D'OR
ARCHITECTURE AWARD

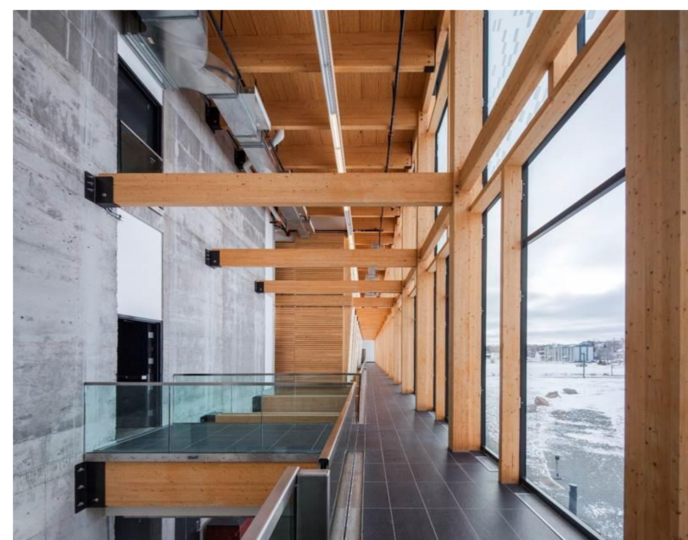

ADMINISTRATION BUILDING OF GSK
QUEBEC, CANADA

WOOD INNOVATION AND DESIGN CENTRE (WIDC)
Prince George, BC, Canada









This concludes The American Institute of Architects Continuing Education Systems Course

NESEA™
NORTHEAST SUSTAINABLE ENERGY ASSOCIATION