Tall Wood:
Fire, Forests & the Future



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ALA, AIA, LEED AP, CSI, GGP

Course Description

Sustainable resources, forest conservation, and fire safety of structures are all considerations for designers with the expanding use of wood structure in commercial and multifamily building types. Expectations regarding fire safety, forest resource harvesting, sustainable forestry designations, and the future, which must consider moisture, durability and sustainability, are topics that often drive materials decisions away from wood. However, science, history and new technology actually support the use of wood as an ideal building material for these considerations and the goals of the 21st Century. Fire resistant construction versus non-combustible construction lies at the core of this direction change. Tragic building fire examples, the status of American forests and the surprising real causes of deforestation will be examined.

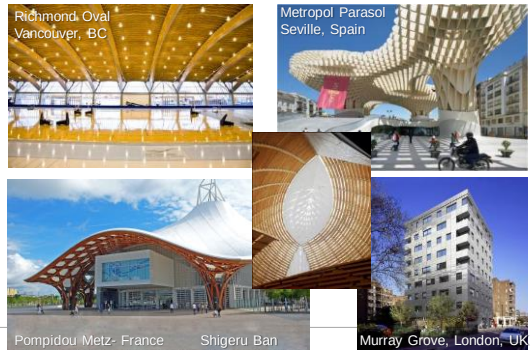
With current sustainability goals striving for carbon neutrality, the concept of carbon sequestration in wood materials and Life Cycle Assessment (the world-wide standard for scientific evaluation of 'green' claims) will be explored. A variety of innovative project examples which incorporate wood and wood hybrid structure highlight this paradigm shift.

Learning Objectives

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

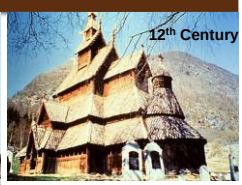
1. Evaluate the **effects of fire** on building materials and the **causes of fire** through review of fire case studies and research science
2. Analyze the state of **forest resources** and evaluate sustainable forestry issues in North America and the rest of the world
3. Assess impacts of **moisture, durability & sustainability** in materials choices
4. Evaluate projects which consider the sustainability of materials selection including **embodied carbon and LCA**

A Wood Renaissance…



…exceeding expectations

Wood – around for centuries…

Horyuji Temple, Ikaruga, Nara, Japan 607-711
12th Century, 1374, 1603

Renaissance = rebirth, resurgence, revival

Barentshus Tower – 20 Stories

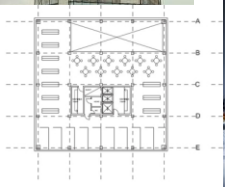
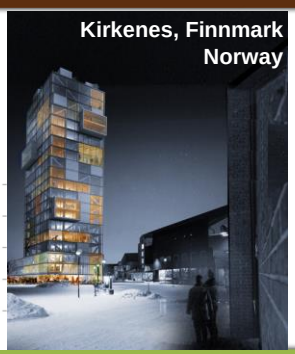




Image credit: Reiulf Ramstad Arkitekter As

Exceeding Expectations…

- **Fire!**
- Forestry
- Moisture & Durability
- Carbon & the Future

Oct. 8, 1871

The Great Chicago Fire - 250-300 killed

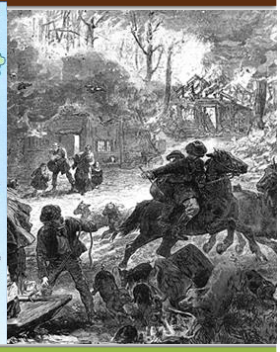
Oct. 8, 1871 - Great Michigan Fire

Manistee, MI
Port Huron, MI
Saugatuck, MI
Holland, MI

Chicago, IL
Peshtigo, WI

Approximately 600 killed

Oct. 8, 1871 – Peshtigo Fire



Peshtigo, Wisconsin - 2,200 killed

The Great Chicago Fire – Oct. 8, 1871

Causes:
Fuel
- Wood Structures **47%**
- Wood sidewalks & roads
- Flammable tar or shingle roofs
- Grease on river banks caught fire
- City's gasworks exploded = fuel

Chicago Buildings -1870
49,781 brick/stone/iron
44,274 wood

The fire department averaged about two fires a day.

250-300 killed

Fire Fighting Resources

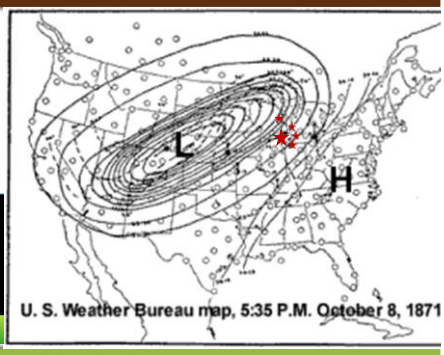
- **Fire-Fighters**
  Exhausted
  Understaffed
  Misdirected

- One water station for city
- Roof collapsed on pumping station at 3:30am

Weather on Oct. 8, 1871

- Drought
- Wind
- **Firestorm**

Peshtigo, WI
Chicago, IL
Manistee, MI
Port Huron, MI
Saugatuck, MI
Holland, MI



U. S. Weather Bureau map, 5:35 P.M. October 8, 1871

Result of the stack effect…heat of original fire draws in more of surrounding air…

Devastating Fires…

- Steel
- Concrete
- Masonry
- Wood

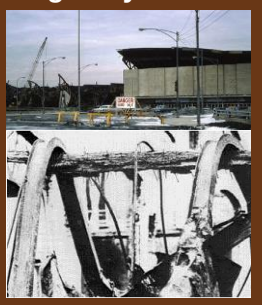
McCormick Place Fire, Chicago Jan. 16, 1967

1960 - McCormick Place
320,000 s.f.
23 meeting rooms
5,000-seat theater.

1967 - FIRE in Fireproof bldg
Roof collapse- 30 min.

Photo source "Great **Chicago** Fires" by David Cowen

Convention Hall Damaged by Fire



A watchman's body was found in the rubble…

Devastating Fires…

- Steel
- Concrete
- Masonry
- Wood

Glulam retains strength in fire…

Glulam remained standing while the rest of the so-called "fireproof" building collapsed.

Turbotech, Inc. in Vancouver, WA

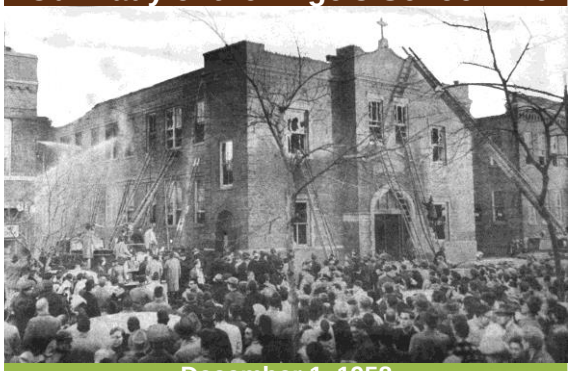
Remy Midrise Fire - 2011

British Columbia, Canada

Devastating Fires…

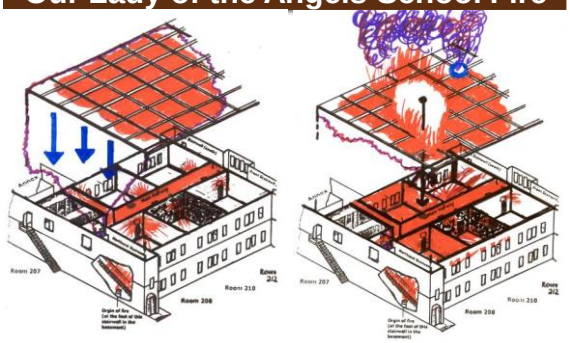
- Steel
- Concrete
- Masonry
- Wood

Our Lady of the Angels School Fire



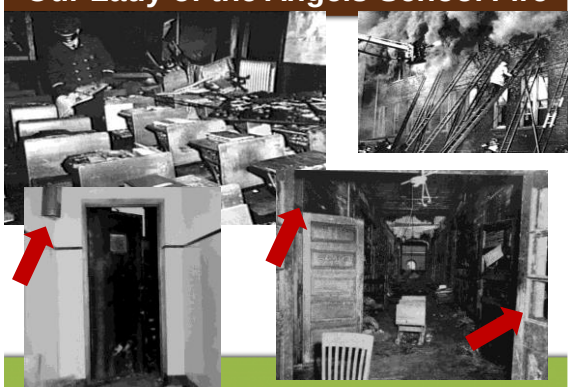
December 1, 1958

Our Lady of the Angels School Fire



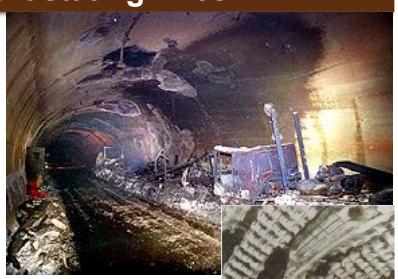
December 1, 1958

Our Lady of the Angels School Fire

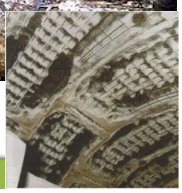


Devastating Fires…

- Steel
- Concrete
- Masonry
- Wood



Channel Tunnel Fire
1996



Concrete and Heat

- **250 – 420** °F: Spalling occurs
- **300** °F: Loss of strength begins
- **550 – 600** °F: Cement based materials experience creep and lose their load bearing capacity
- **600** °F: Greater than this temperature, concrete is not functioning at its full structural capacity
- **900** °F: Temperature of Flame

Concrete after fire…

A Fool's Paradise – Dec. 30, 1903

"…the plush upholstery burned off the seats, the wooded parts remaining intact."

602 killed, 250 injured in 8 minutes

Chicago Iroquois Theater - Concrete

High Rise Fires – Steel & Concrete

1988
First Interstate Bank Building, Los Angeles

1991
One Meridian Plaza, Philadelphia

2005
Windsor Building, Madrid, Spain

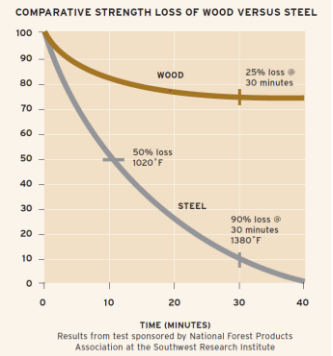
What protects PEOPLE from fires?

- **Smoke Alarms**
- **Sprinklers**
- **Firestopping**
- **Exiting**
- **Endurance of building materials**
  - Combustibility
  - Protected or Unprotected
- **Enclosure Systems**
- **Building CODES!**

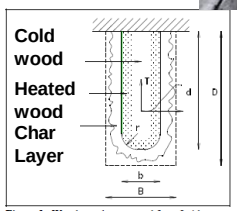
EXIT

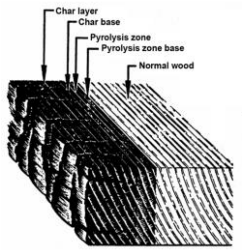
How do wood and steel beams compare?

Heavy Timber resists fires through <u>charring</u> and maintains <u>strength</u>



Heavy Timber Fire Design

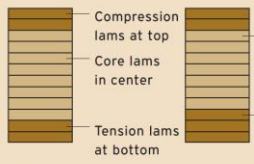




Char protects the inner core.

http://www.awc.org/pdf/tr10.pdf

ADAPTING STANDARD BEAM LAY-UP TO MEET ONE-HOUR FIRE RESISTANCE



The basic lam lay-up can easily be modified to qualify for 1-hour fire rating by removing one core lam from center of member and adding one additional tension lam to tension face, assuming all require-ments are satisfied.

Steel Studs vs. Wood Studs

- Wood Frame
- Steel Frame

Which will be safer in a fire?

Steel Stud Construction

"…collapsed without warning in 10-15 minutes… steel studs, joists & trusses…"

http://www.fireengineering.com

Steel Studs - Catastrophic Collapse

Photo by J. Shepherd, district chief, Brevard County (FL) Fire Rescue

Penetrations

Properties - Structural Steel

- **400F** – Begins to lose strength
- **1,200 F** - Lost more than 60% of strength
- **1,000 F** – Expect to fail, elongates

Quiz:

A 100 ft. Steel beam heated to 1,000F will expand. How much?

9 ½ Inches

NFPA TODAY
YOUR ONLINE NFPA COMMUNITY

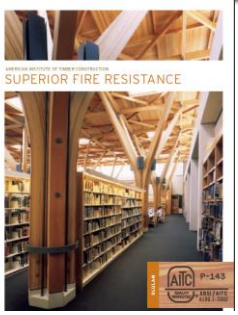
Fire Safety of Tall Wood Buildings

ARUP

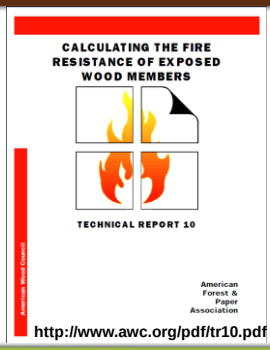
THE FIRE PROTECTION RESEARCH FOUNDATION

Build fire-safe buildings with wood.

Fire Resistive Construction Resources

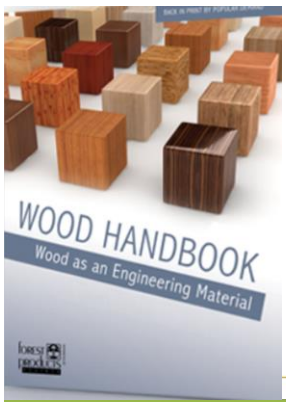


Public Library, Beaverton, OR.



http://www.awc.org/pdf/tr10.pdf

http://www.aitc-glulam.org/shopcart/Pdf/superior%20fire%20resistance.pdf

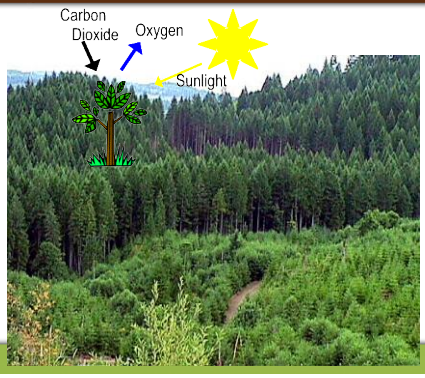


http://www.fpl.fs.fed.us/documnts/fplgtr/fpl_gtr190.pdf

Exceeding Expectations…

- Fire!
- **Forests**
- Moisture & Durability
- Future

Carbon Absorbed & Sequestered



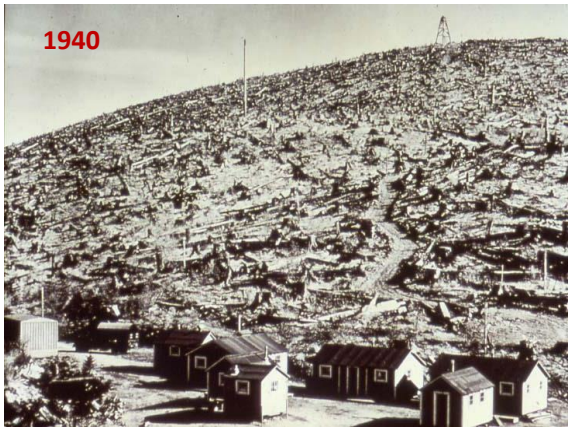
Carbon Stored

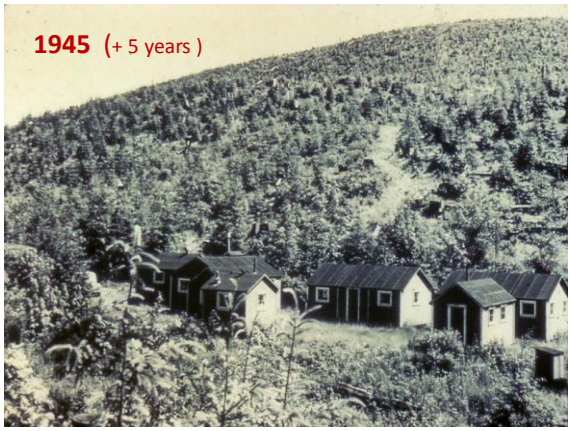
Forests

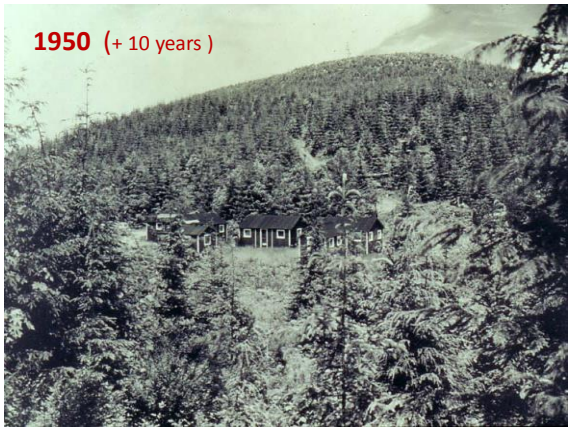
Forestry Practices

Clear-cutting ≠ **Deforestation**

= **Scientific practice to help accelerate forest regeneration**

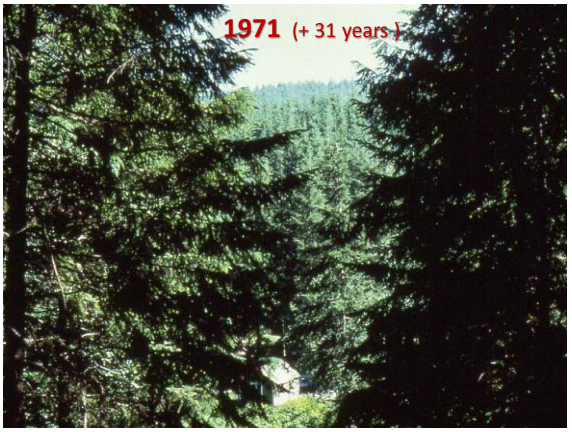





1950 (+ 10 years)


1955 (+ 15 years)

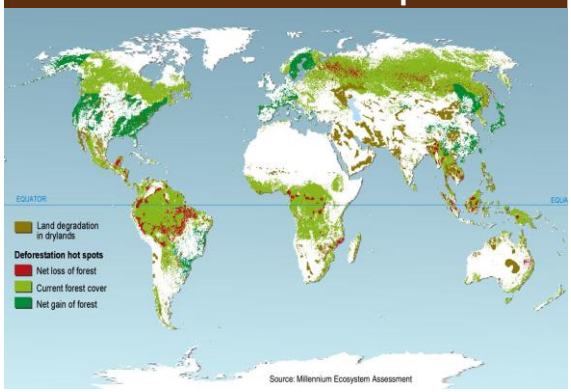

1961 (+ 21 years)


1971 (+ 31 years)


1974
(+ 34 years)
DOVETAIL PARTNERS INC.
A Trusted Source of Environmental Information


Fire & Forests

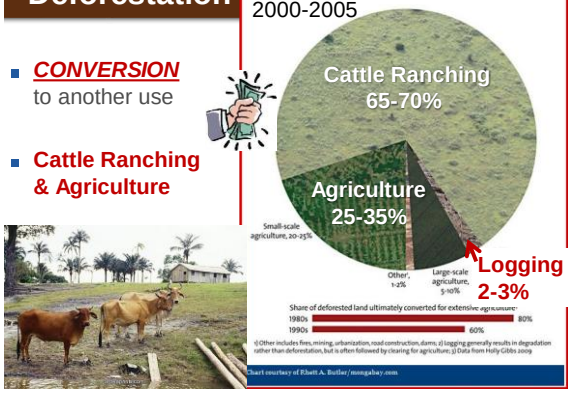
Deforestation Hot Spots



Deforestation

- ***CONVERSION*** to another use
- **Cattle Ranching & Agriculture**

Causes - Brazilian Amazon 2000-2005



Ensure Sustainable Forests

Forest Stewardship Council

Addresses social issues w/ international reach into countries where no legal and institutional framework for social rights and values

Programme for the Endorsement of Forest Certification Schemes

Global Umbrella organization supported by 149 governments, covering 85% of the world's forest area

Global Sustainable Forestry

Australia, Austria, Belgium, Brazil, Canada, Chile, Czech Republic, Denmark Estonia, Finland, France, Germany, Italy, Luxembourg, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States

Global Sustainable Forestry

PEFC Certified Forestry

Canadian Standards Association

- Public land
- Rigorous public participation process

Sustainable Forestry Initiative

- Private land
- Public land
- www.sfiprogram.org

American Tree Farm System

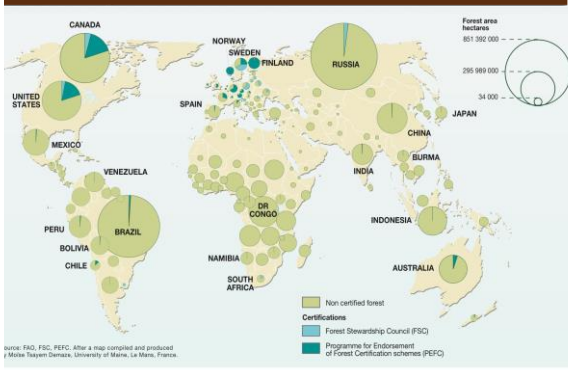
- Affordable certification for family & small forest landowners

Commercial Green Building Rating Systems

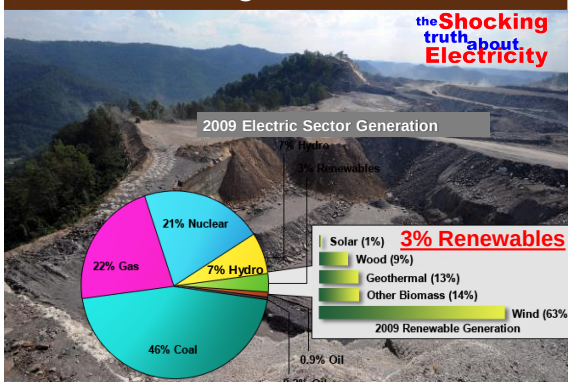
- LEED U.S.
  - FSC
- GREEN GLOBES
  - FSC
  - PEFC
    - ATF
    - CSA
    - SFI
- BREEAM & IGCC
  - FSC
  - PEFC
    - SFI
    - ATF
    - CSA

USGBC is the *ONLY certifier in the WORLD* that does *NOT* accept PEFC

Certified Forests around the World



Coal Mining = Deforestation



Think About the Messages…

thinkbeforeprinting.org
Please consider the environment before printing

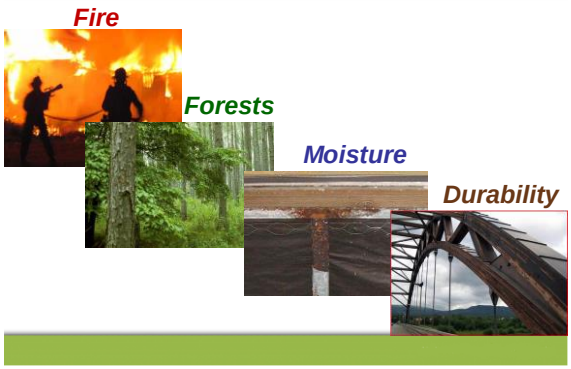
"Dryers help protect the environment. They save trees from being used…"

Glacier National Park
2011

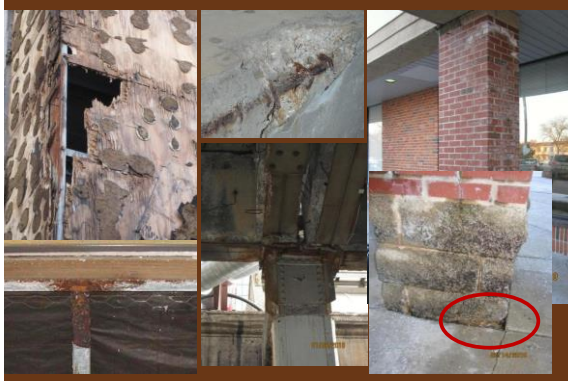
Mountain Pine Beetle Epidemic

Richmond Oval – Vancouver Olympics

Exceeding Expectations…



Materials & Moisture



MOLD - No building material is exempt…

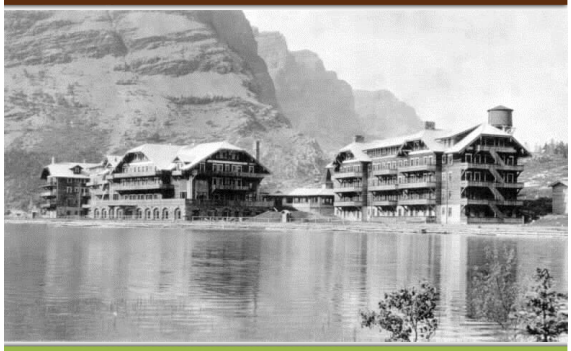
Moisture + Dust/Dirt = Mold

Do Materials = Long Life Span?

Bertrand Goldberg
Built 1975
Useful life:
37 years???

Prentice Women's Hospital, Chicago

Many Glacier Hotel, Montana



Built - 1915

Five Story Wood Structure

Many Glacier Hotel,
Glacier Nat'l Park, MT

1915 - ?

Butler Brothers Building – 9 Stories

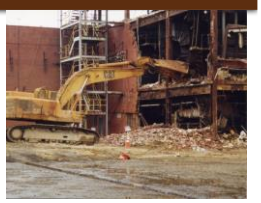
Built 1906 500,000 s.f.

Butler Square today…

Architect: Harry W. Jones Renovated 1974

Structural System = Long Useful Life?

- No Relationship!



Reasons for demolition

- Changing Land values
- Lack of suitability
- Lack of maintenance

http://www.cwc.ca/NR/rdonlyres/67D42613-BF5D-4573-BD43-C430B0B72C08/0/Service_Life_E.pdf

Exceeding Expectations

- Fire!
- Forestry
- Moisture & Durability
- **Carbon, LCA & the Future**

Life Cycle Assessment – 1960's

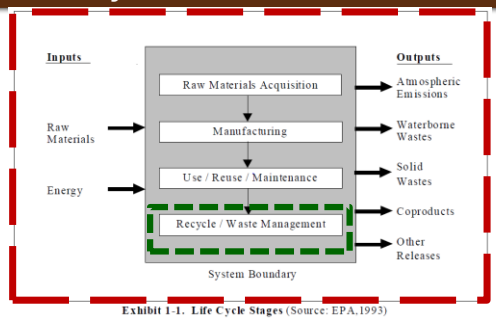


Exhibit 1-1. Life Cycle Stages (Source: EPA,1993)

Consider system boundaries…

http://www.epa.gov/nrmrl/std/lca/pdfs/600r06060.pdf

Life Cycle Assessment

From cradle to grave… or cradle to cradle.

Life Cycle Assessment - Steel

http://www.steel.org

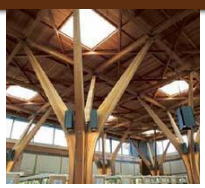
Life Cycle Assessment - Concrete

http://www.cement.org/basics/howmade.asps

Life Cycle Assessment-Wood

Using wood materials in new ways…

Bellevue Transit Station



Beaverton Library, OR

Bridges - Norway

Sentinel Structures

Innovations in Materials

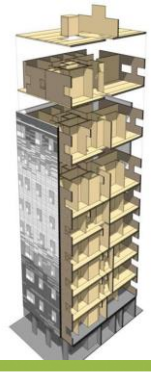
20 story building in Norway

16 storey building, Italy

Concept of 36 story building

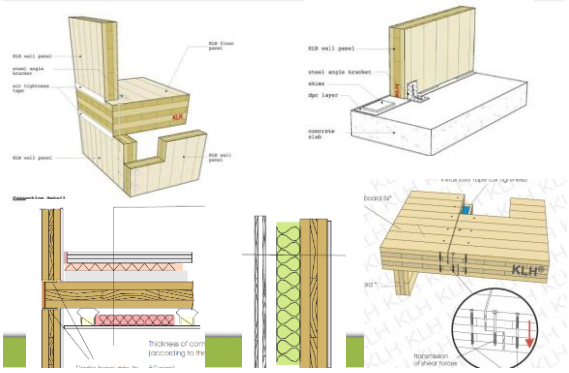
Tall Wood

Cross Laminated Timber (CLT)

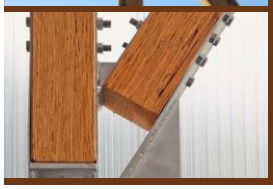


Photos provided by FPInnovations

How does CLT work?



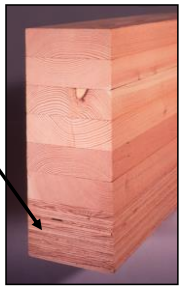
Heavy Timber Braced Frames (HTBF)



Glulam with LVL Tension Lamination

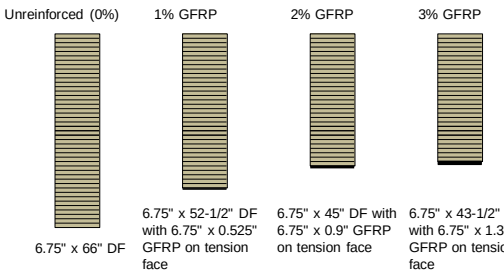
LVL Tension Lam

- **Full length- no finger joints**
- **Greater tensile strength = 3000 psi**



Glulam Floor Beams - EWS C415 & Y117

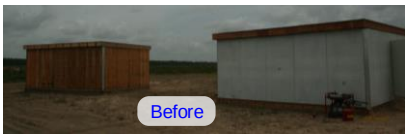
Fiber Reinforced Polymer (FRP) Glulam



Fiber Reinforce Polymers (FRP)

- Tension reinforced Glulam
- FRP reinforced shear walls
- Blast Resistant technology

FRP use in Blast Resistant testing

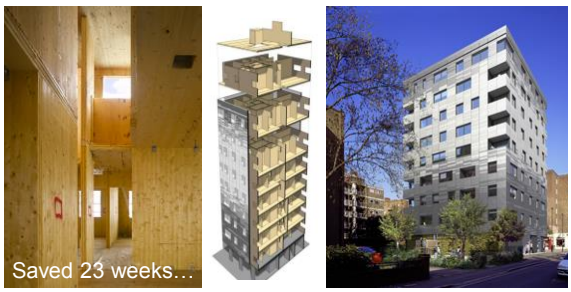


Blast Testing Results

Post Tensioning

- Moment connections for Heavy Timber
- Rapid erection
- Lightweight
- Low carbon footprint
- Earthquake resistant

Nine Story Wood Building in UK - 2010



Architect: WaughThistleton Architects – London, England

Carbon storage = 210 years of 10% reduction in CO2

Construction - Minimal Site Waste

H8 – Bad Aibling, Germany 2011

Const. assembly = 16 days
1 story every 2 days…

Schankula Architekten

Melbourne - Victoria Harbour at Docklands – Forté

Lead Lease – Australia 2013 10 Stories

Via Cenni, Milan, Italy

4-Building Social Housing – 9 Stories of CLT

Via Cenni, Milan, Italy

(Bernasconi, 2012)

Research Studies & Proposals

34-story Timber Tower -Stockholm

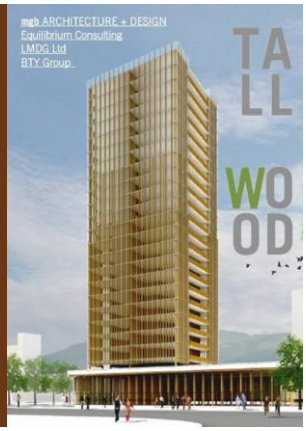
Architects Berg | CF Moller Architects

The Case for Tall Wood Buildings

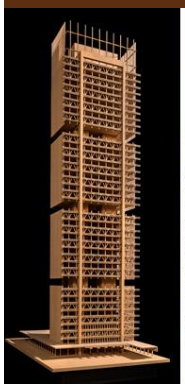
Architect: Michael Green
Engineer: Eric Karsh

30- story timber tower study - Canada

www.woodworks.org

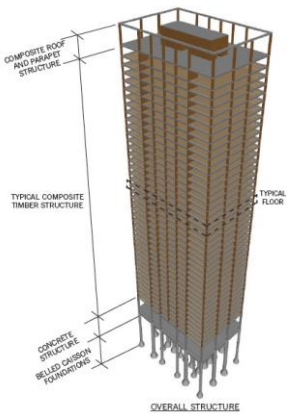


An Office Building of the Future

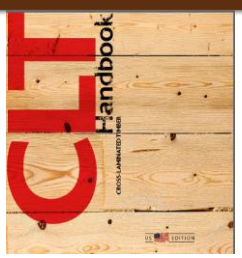


CEI Architecture - Canada

Timber Tower Research - SOM



Cross-Laminated Timber - CLT



Available in the U.S. & Canada…

www.masstimber.com

Recreation & Aquatics Facilities

Pyramidekogel tower - Austria

Pyramidenkogel - Austria

Architect: Klaura & Kaden
Engineer: Markus Lackner

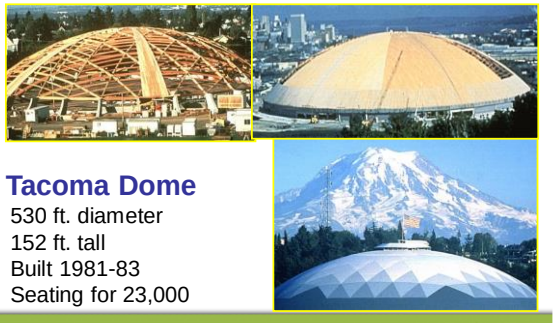
Height: **328 ft**. /100 m
Visit platform: **272 ft.** /83 m
Café: **229 ft.** / 70 m
LongSlide: 170 ft. / 52 m

Completed in 2013

Tallest Timber Observation Tower

Pyramidenkogel - Austria

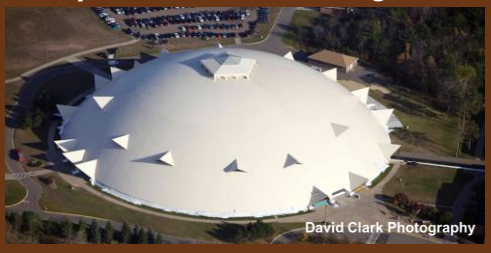
World's Largest Wood Dome ?



Tacoma Dome
530 ft. diameter
152 ft. tall
Built 1981-83
Seating for 23,000

Architect: McGranahan & Messenger, Tacoma, WA

Superior Dome - Michigan



14 Stories tall; Diameter of 536 ft. ; 5.1 acres
781 D.F. beams
108.5 miles of fir decking.
Snow loading to 60 pounds per square foot &
80 mile per hour winds.

Superior Dome - Michigan

Civic & Cultural Facilities

Metropol Parasol, Seville, Spain
Design Team: J. Mayer H. Architects, ARUP Consulting Engineers
Photo Credit: ARUP

Metropol Parasol, Seville, Spain
Design Team: J. Mayer H. Architects, ARUP Consulting Engineers
Photo Credit: ARUP

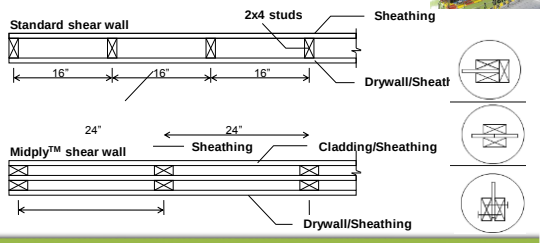
Midrise Residential & Office

NEESWood Capstone

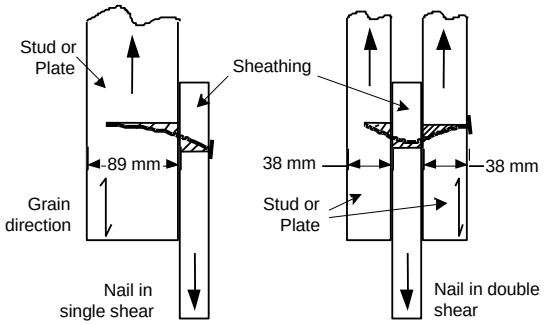
Miki City, Japan
July 6, 2009
Shake Table Test

http://www.nsf.gov/neeswood

Midply Shearwalls



Mid-Ply Shearwalls



Fire Retardant Treated Wood

Fire- retardant process is throughout the material.

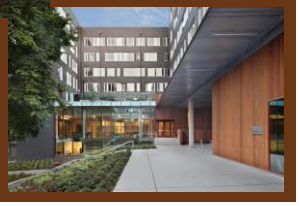
Marselle Condos

Case Study: University of Washington

Architect: Mahlum Architects

Engineer: Coughlin Porter Lundeen

Contractor: Walsh Construction



<u>UW West Campus Student Housing</u>
Location: Seattle, WA
1700 beds in 3 halls and 2 apt bldgs
$177/sf
4/5 bldgs met 2030 challenge

University, School & Research Facilities

UBC Earth Sciences Building

Vancouver, BC

Images: Kris Spickler - Structurlam

UBC Earth Sciences Building

Images: Kris Spickler - Structurlam

UBC Earth Sciences Building

CrossLam roof and floor system with glulam beams

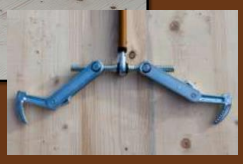
Images: Kris Spickler - Structurlam

Speed of Construction

CLT Panels being placed one every 15 minutes

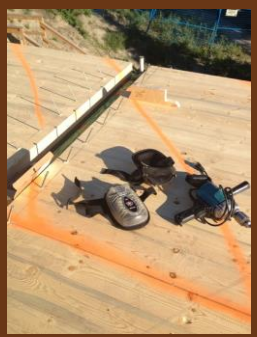
Images: Kris Spickler, Structurlam

CrossLam Panel tight-fit tool



Images: Kris Spickler - Structurlam

Typical Panel Connectors



Images: Kris Spickler - Structurlam

UBC Earth System Science Building

CLT roof panels

Images: Kris Spickler - Structurlam

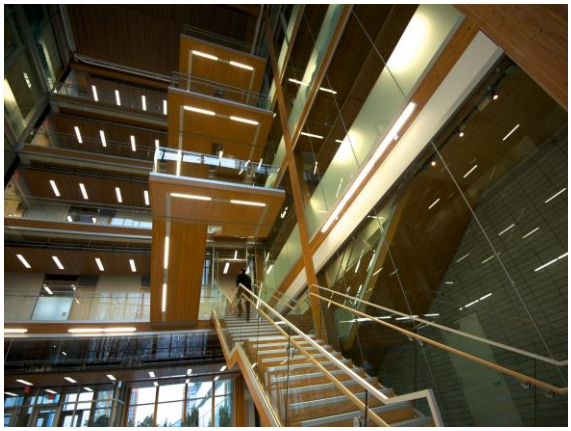
CLT panels are a problem solver at eave corners

Images: Kris Spickler - Structurlam

Bonus feature

Stairway – partially unsupported Glulam/CrossLam construction

Images: Kris Spickler - Structurlam



What is Next?! .. Tall Wood

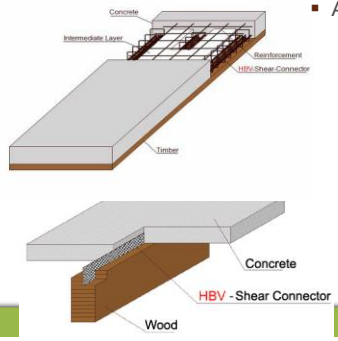
Life Cycle Tower

Passivhuis standard …
All components - local and prefabricated.

CREE designed structure to be built in Dornburn, Austria

HBV floor panels

Composite action – reinforced concrete and wood

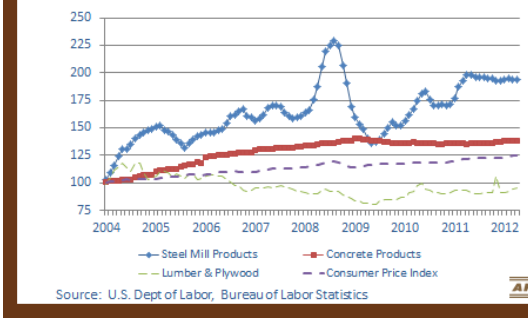


- Alternatives for:
  - Reinforced-concrete floors
  - Conventional steel composite systems
  - Flexural and two-way load bearing planks
    - Pre-stressed steel concrete hollow box floor

Wood Cube vs. Concrete Cube

Construction Materials Price Index

Change in producer prices. December 2003 = 100



Source: U.S. Dept of Labor, Bureau of Labor Statistics

APA

The benefits of using wood…

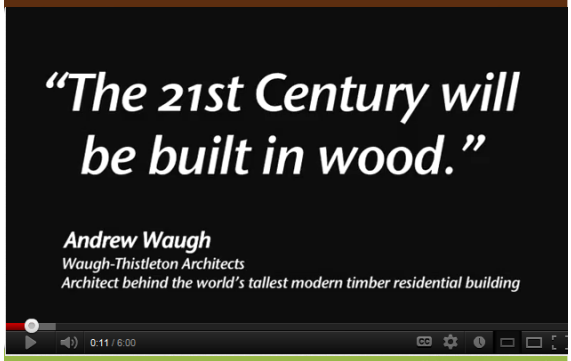
- Cost
- Faster construction time
- Easy to work with
- Aesthetics
- Sustainability
- Carbon
- Renewable

Wood is Good!

WOOD is the ONLY material:

Renewable & provides assurance of
Environmental Responsibility
regarding production.

Tall Wood???



Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

THANK YOU!

Cheryl A. Ciecko

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cheryl.ciecko@live.com