Chapter 1 Introduction to Timber Structures

CIVE480 Timber Structures
2019

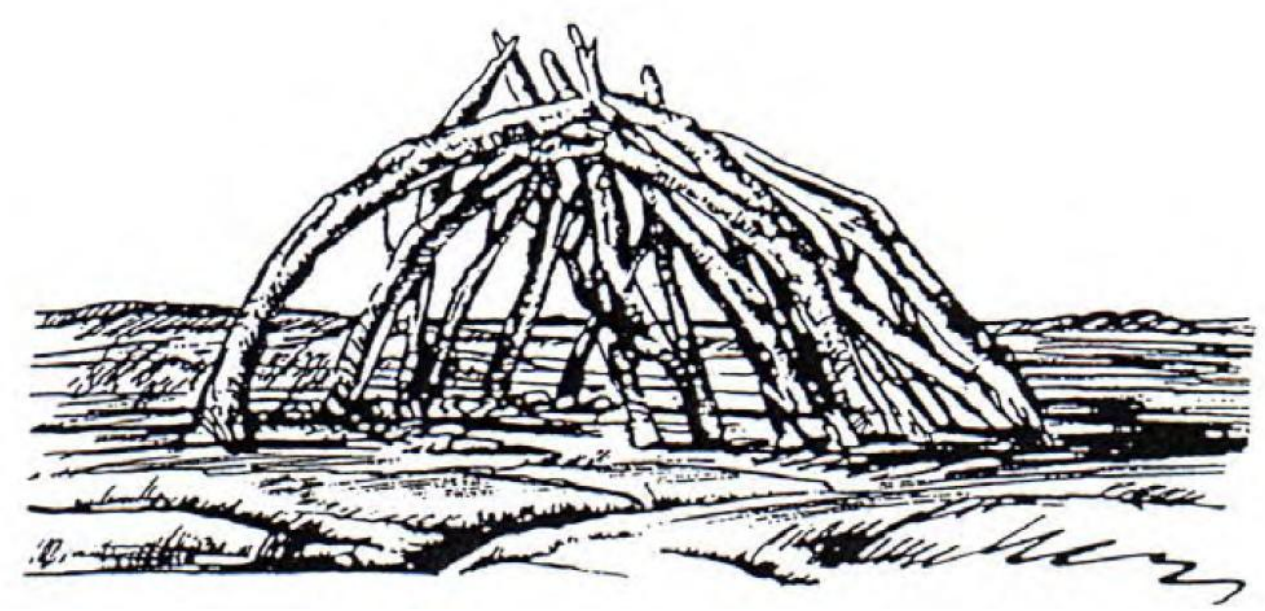
University of Victoria

1.1 Timber Structures in History

1) Earliest shelters (Europe)

- *"Timber has been available as a construction material for most societies since the human race first started to build crude shelters at the dawn of civilization." (Kuklik 2008) [1]*

- Tree branches
- Covered with grass
- Circular floor plan

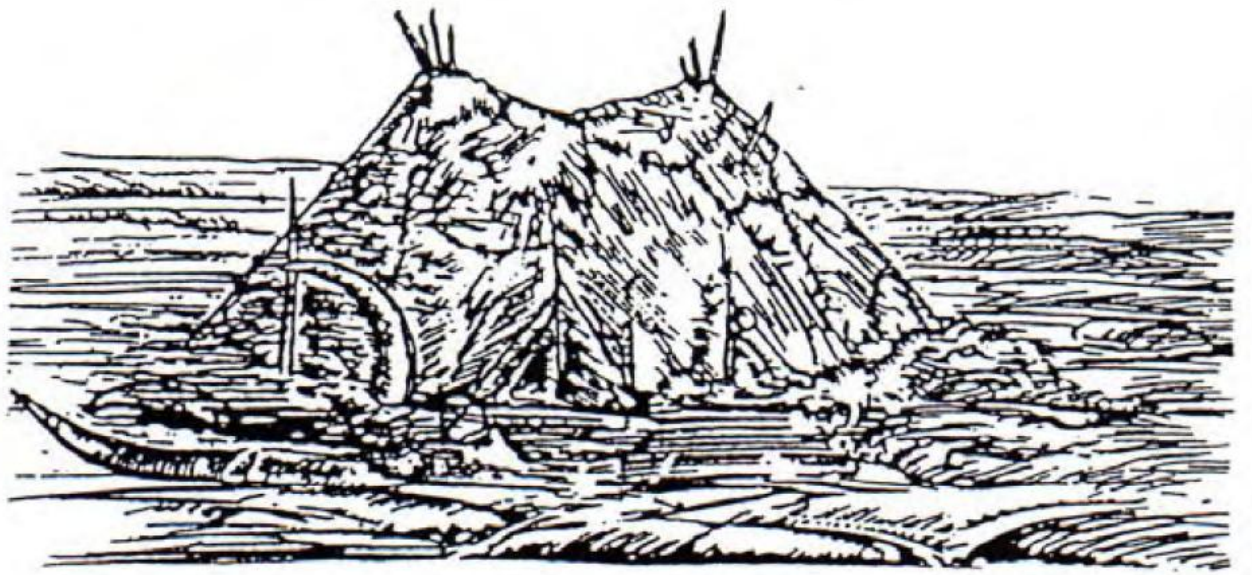


The shelter framework of primeval man (120 000 – 40 000 BC) [1]

1) Earliest shelters (Europe)

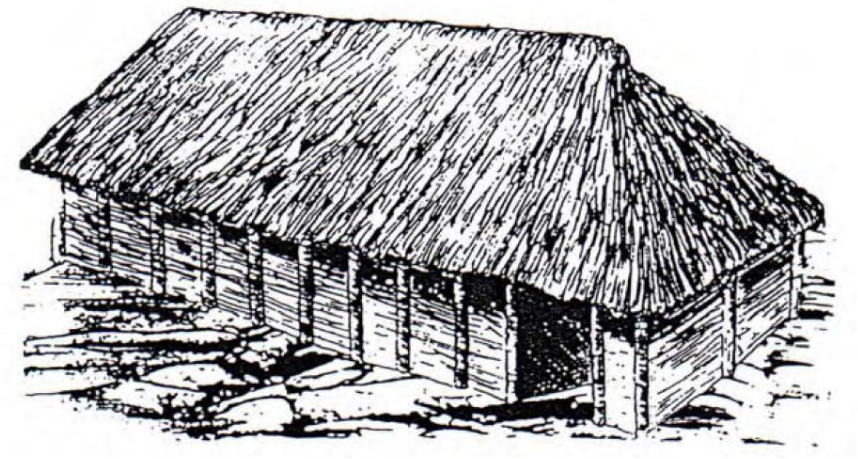
- *"Timber has been available as a construction material for most societies since the human race first started to build crude shelters at the dawn of civilization." (Kuklik 2008) [1]*

- Tree branches
- Covered with hides
- Elliptical floor plan

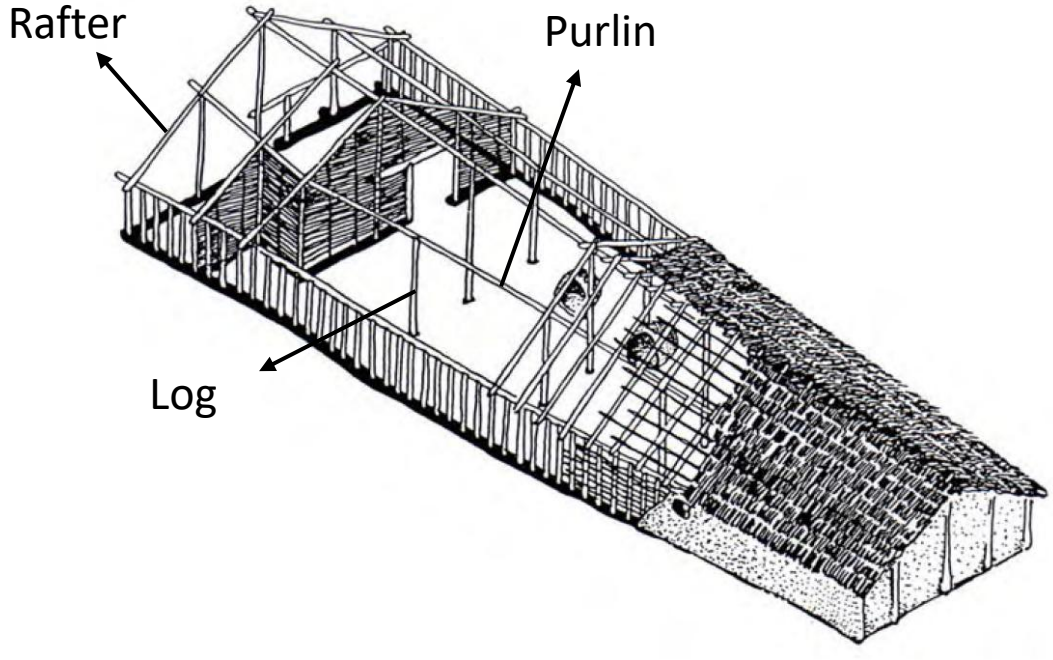


Primeval mankind shelter (40 000 – 10 000 BC) [1]

2) First timber-framed houses (Europe)



Longhouse (4 500 BC) [1]

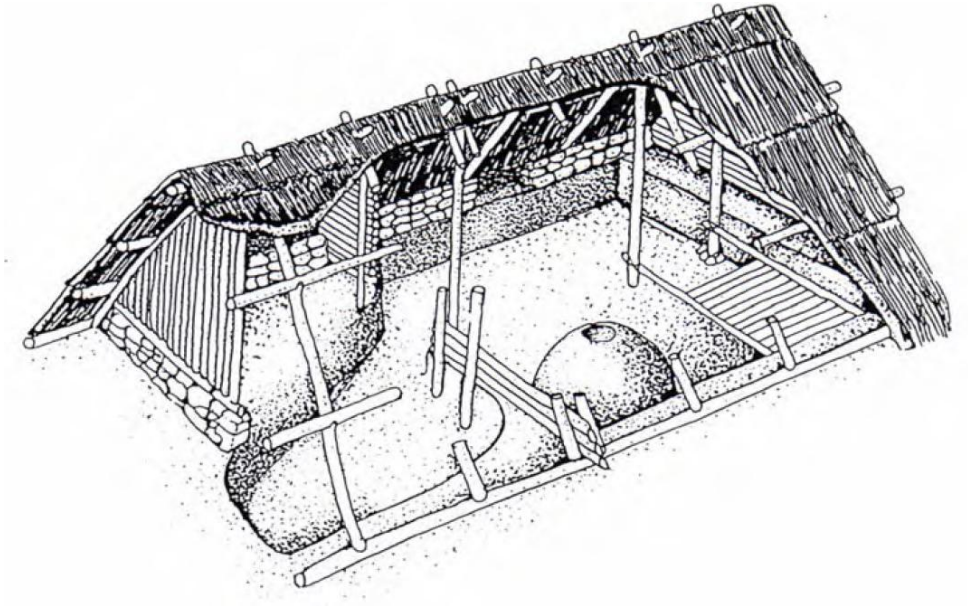


Longhouse (3 000 BC) [1]

- Durability: less than 20 years
- Floor: 5.5-7m width, 20-45m long

- Floor: a little trapezoidal
- No windows

3) Timber-framed houses (Europe)



House constructed by the Celts (400 BC) [1]

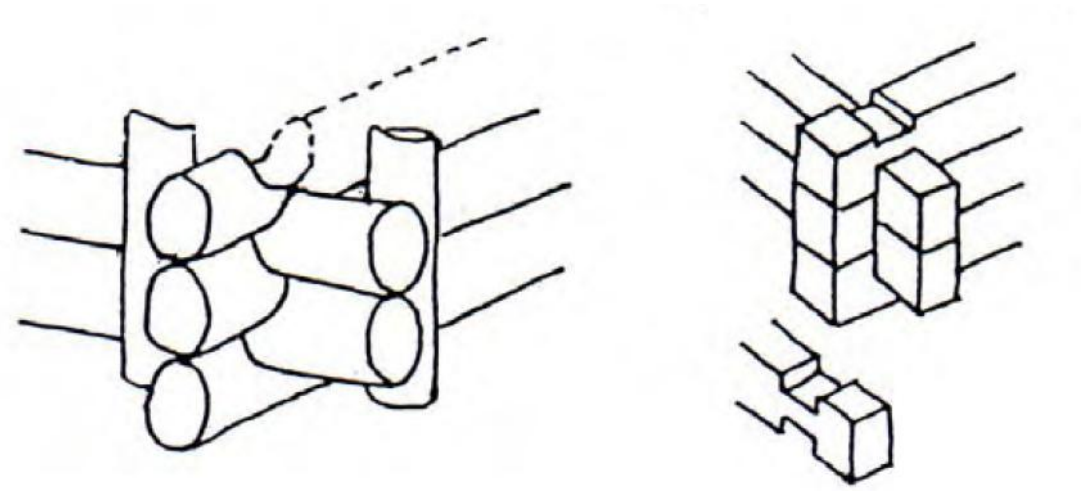
- Stone pedestal

House constructed by the Teutons (0 - 500 AD) [1]

- Primitive and small (5m×6m or 4m×5m)

4) Rural houses (Europe)

- Between the 13th to the 15th century: timber, stone (foundations and walls) and clay (nogging)

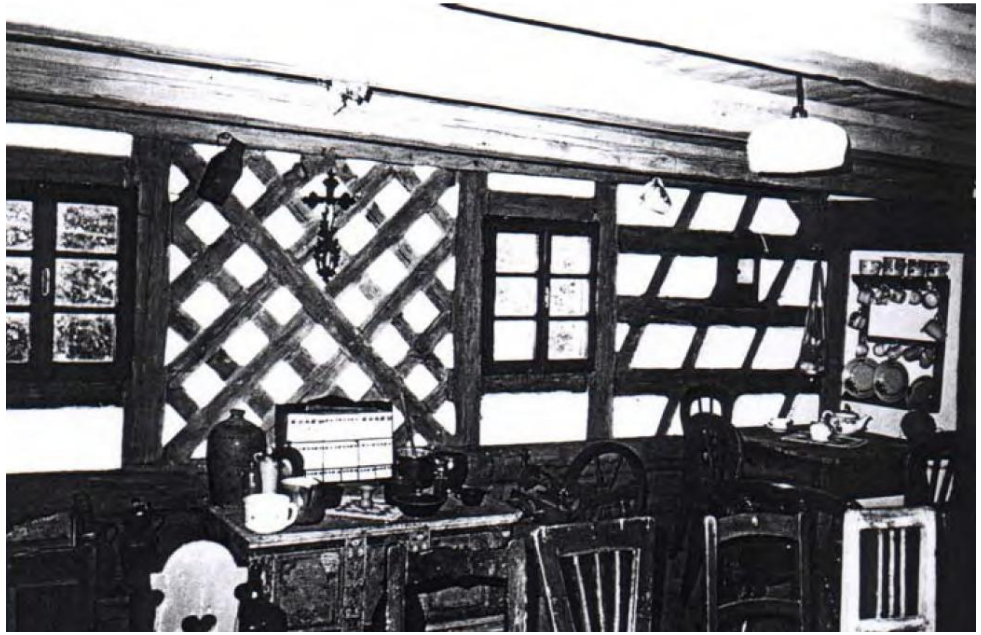


Details of log house corners [1]

- Logs laid horizontally to form walls
- Notching at the corner intersections to provide stability

4) Rural houses (Europe)

- Half-timbered house: short logs, clay (nogging)

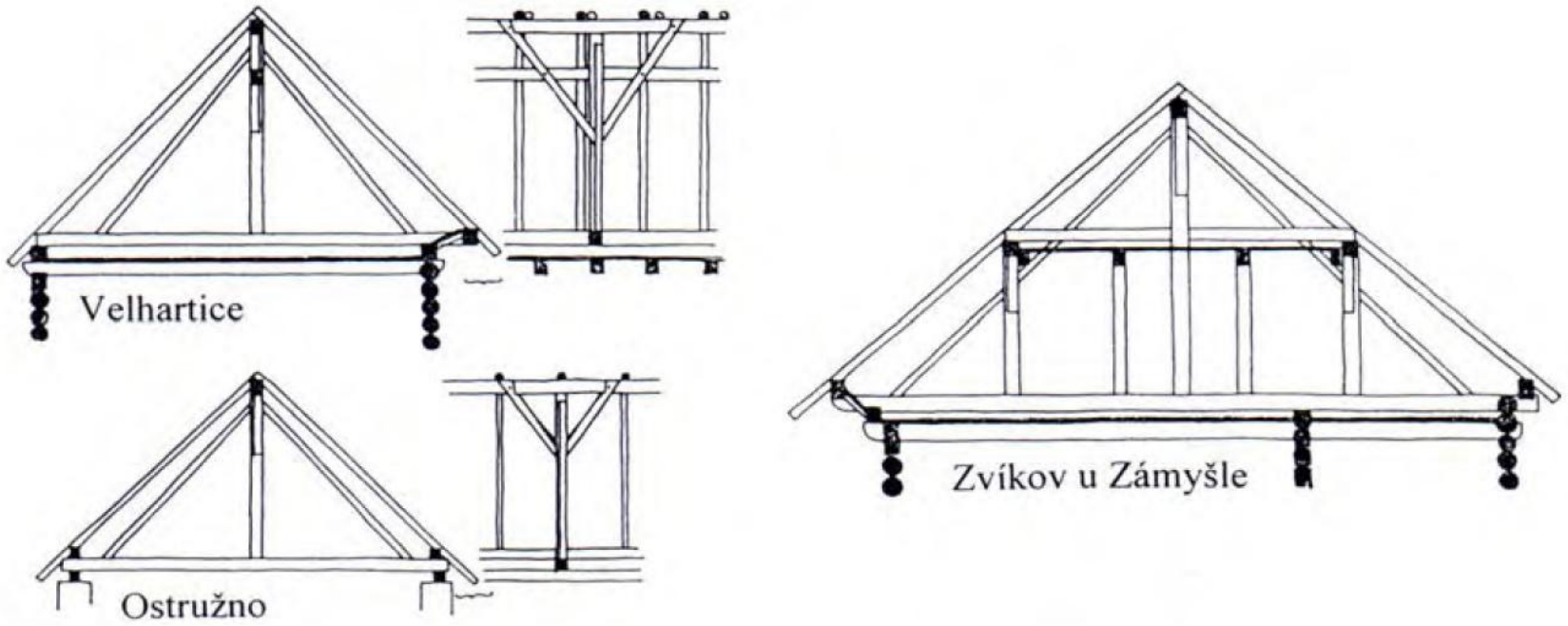


Half-timbered wall [1]

- 12th century in Germany, first used in town houses
- 15th century, also used in rural houses

4) Rural houses (Europe)

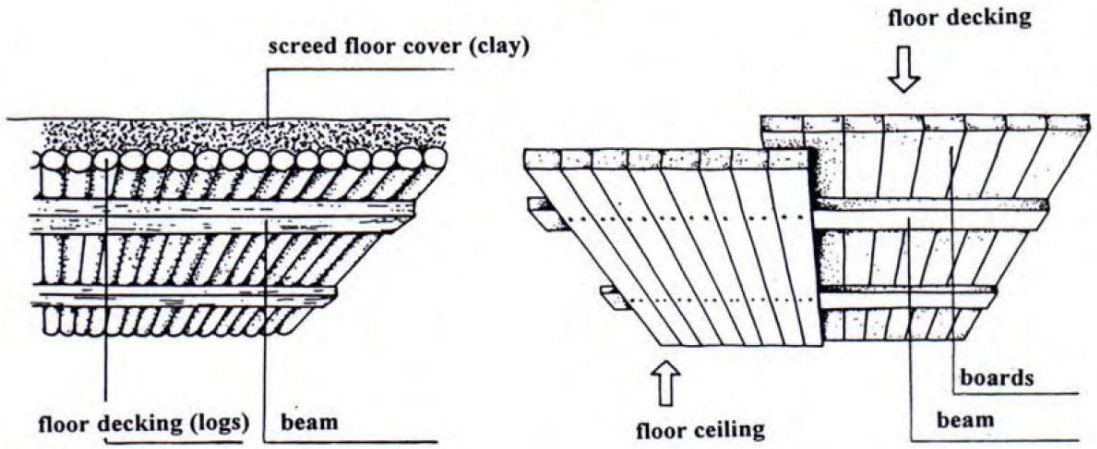
- Bracing used in the longitudinal direction



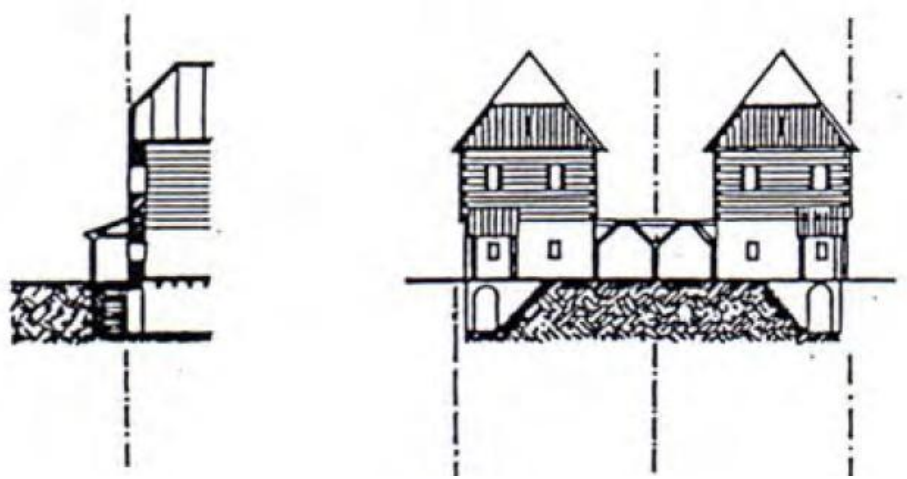
Roof Structures [1]

5) Urban houses (Europe)

- 14th century, stone and brick as structural materials (fire resistance)
- 16th century, brickwork structures (predominant)
- 18th century, timber prohibited in towns, except for floors, separating walls and roofs



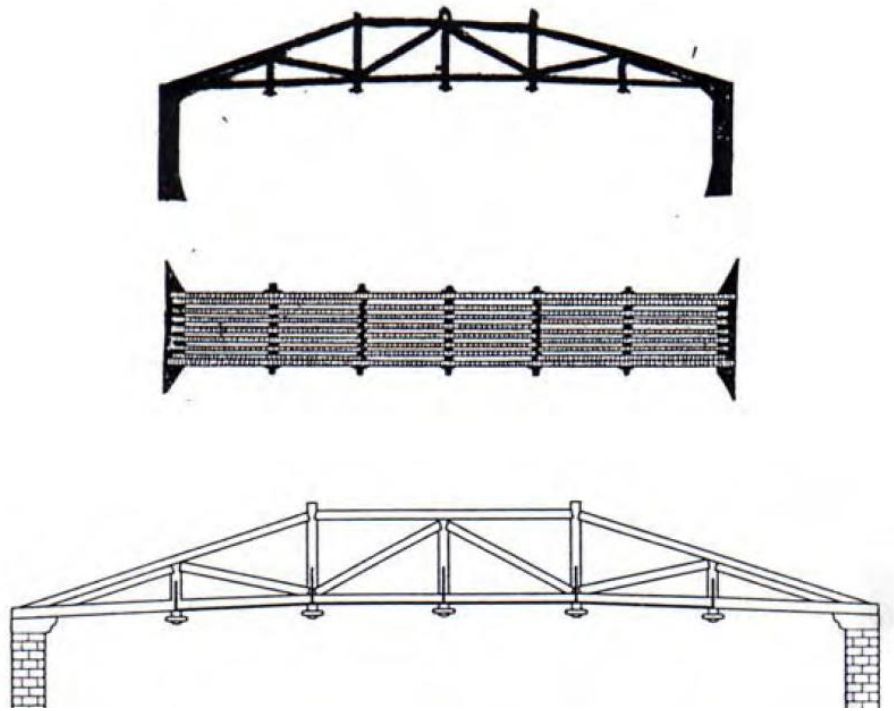
Floor structures [1]

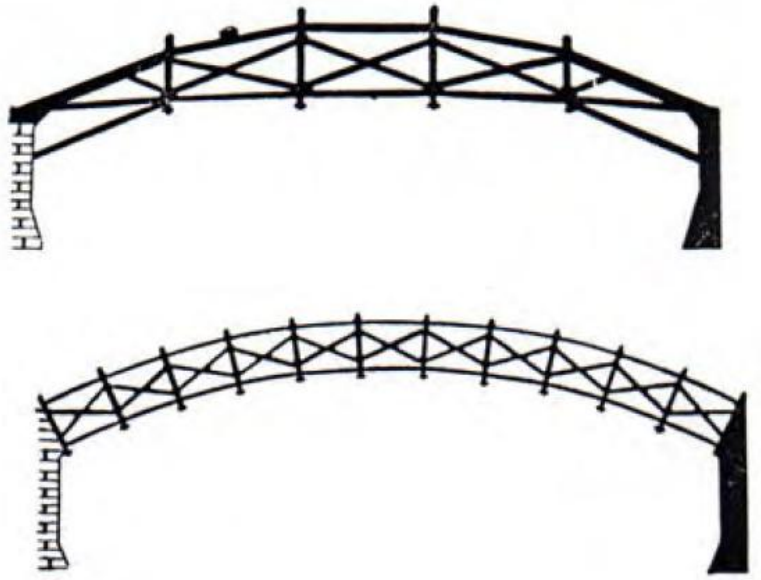


Attaches house [1]

6) Timber bridges (Europe)

- The oldest know timber bridges go back to 600 BC

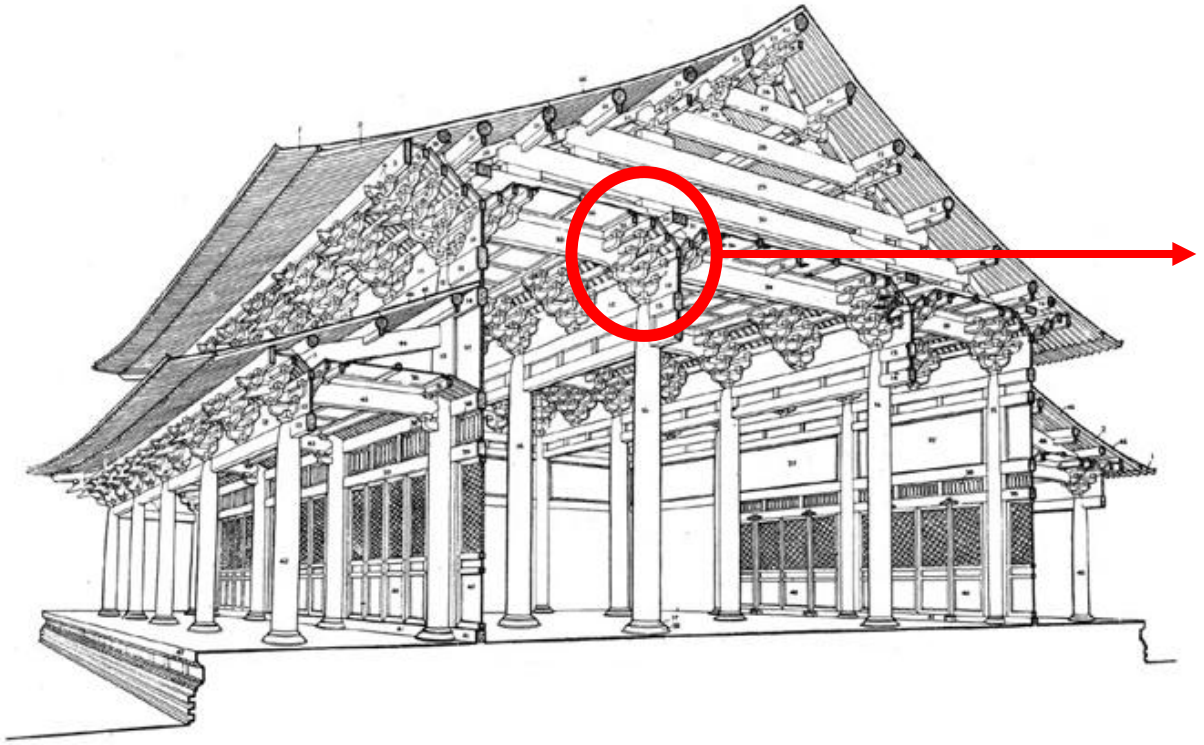




Trussed bridges (Palladio 1570) [1]

7) Timber structures (China)

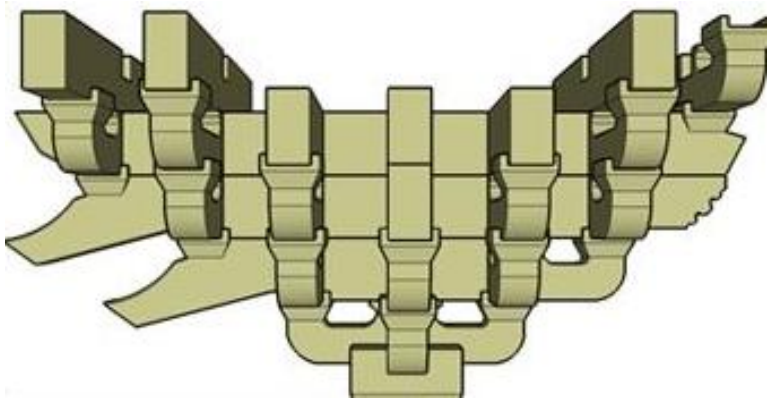
- Since 1500 BC, Tenon and Dougong connections have been used in traditional Chinese timber structures.

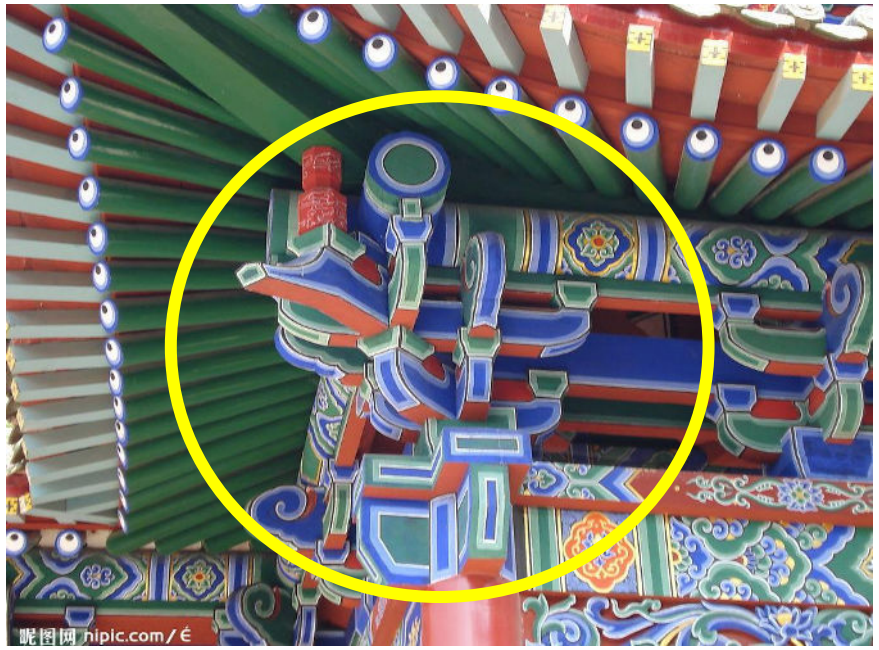


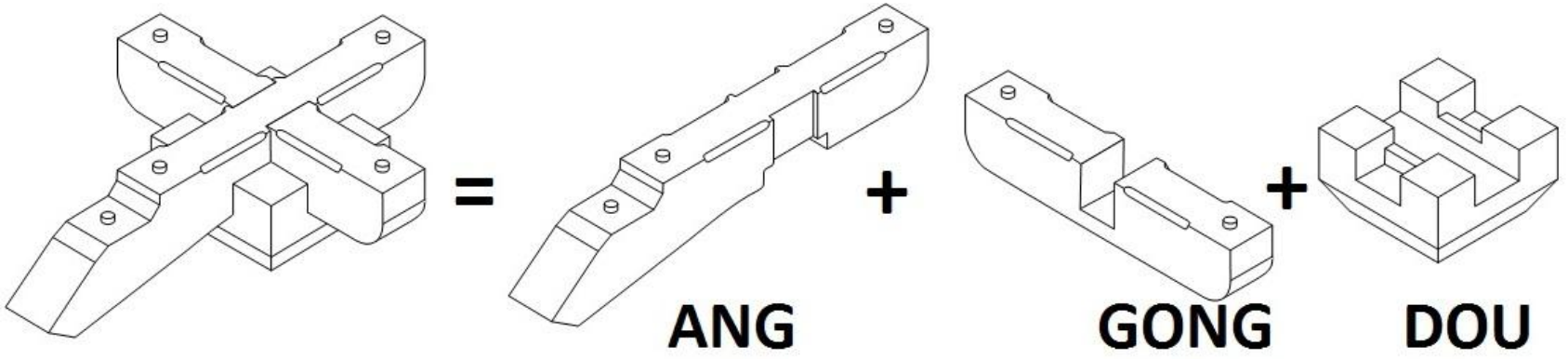
Post-beam structures (Yingzao Fashi)

- Dougong: a unique structural element of interlocking wooden brackets

8) Dougong (China)







THE DOU GONG BRACKET SYSTEM

9) Yingxian Pagoda (China)

- Built in 1056
- Height: 67.31m
- 54 different kinds of Dougong connections
- Survived several large earthquakes throughout the centuries

1.2 Current Timber Structures and Trends

1) Light wood frame structures

- Residential buildings
- Up to 6-storey (BC 2009)

Single family house

(Susan M Boyce)

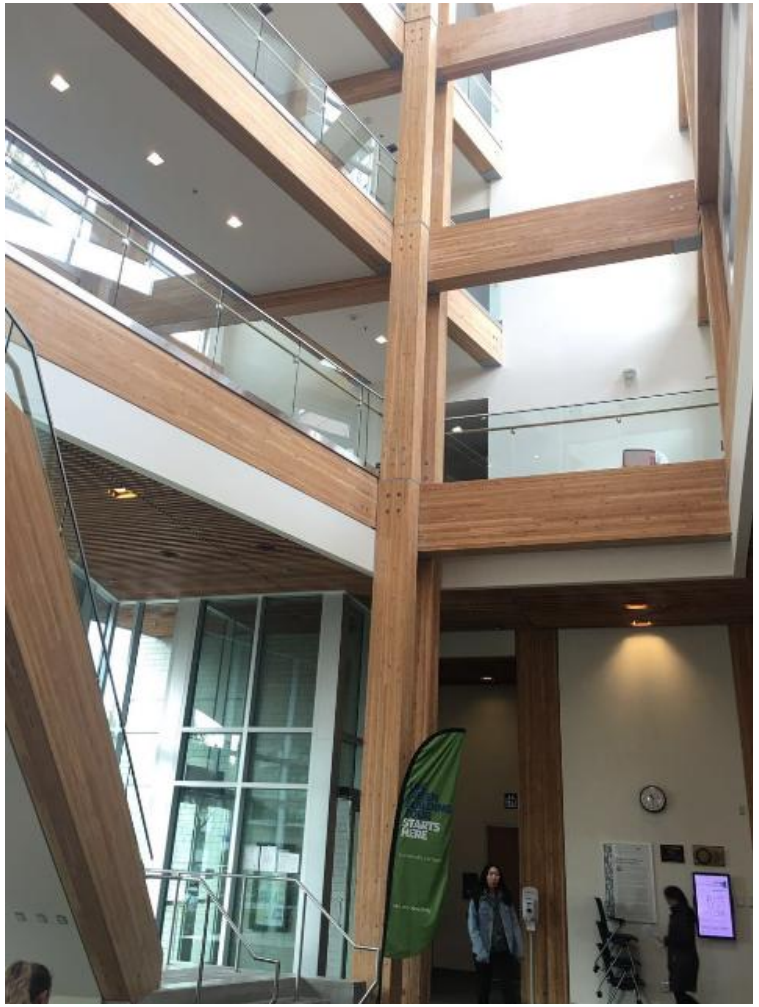
Multi-story apartment under construction

2) Heavy timer structures

- Commercial buildings
- Structures exposed

(Western Wood Structures, Inc.)

A car museum in Tacoma WA



The Centre for Interactive Research on Sustainability (UBC)

3) Mass timber structures

- Mass timber panel

(kihusa.com)

Cross laminated timber (CLT)

(structurlam.com)

Wood Innovation and Design Centre (UNBC)

4) Hybrid timber structures

(Liz Brown)

Reinforced concrete podium and core
+ CLT floor and Glulam column

(Idaho Airships Inc.)

Reinforced concrete podium
+ light wood frame structure

4) Hybrid timber structures

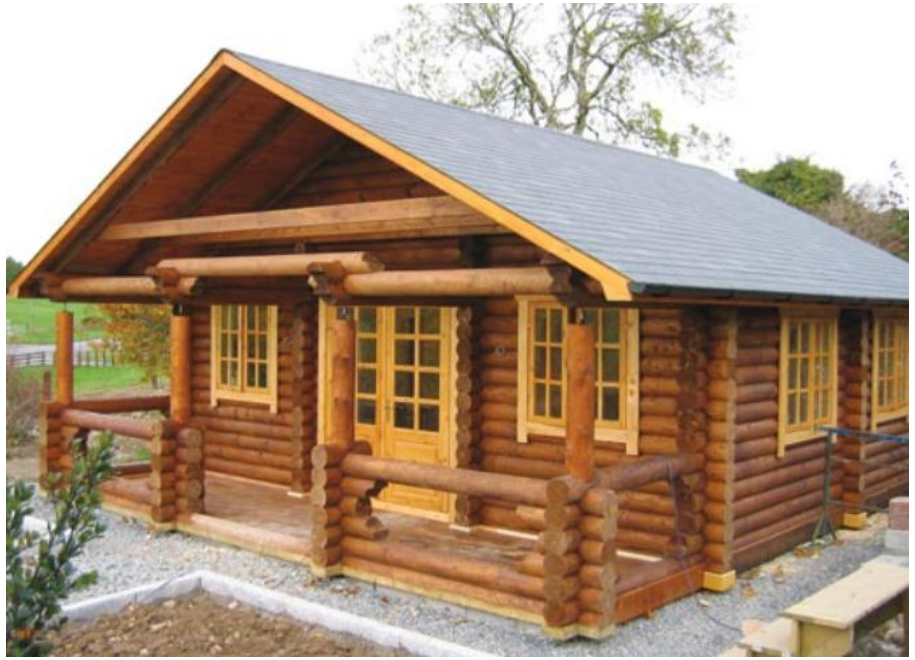
(structurlam.com)

Timber floor and column
+ steel lateral bracing

https://www.pinterest.ca/oguzakdenizz/roof-structure/

Hybrid timber-steel roof

5) Other timber structures



(Wildwood Log Cabins)

Round log cabin

(AWR)

Metropol Parasol, Spain

6) Trends

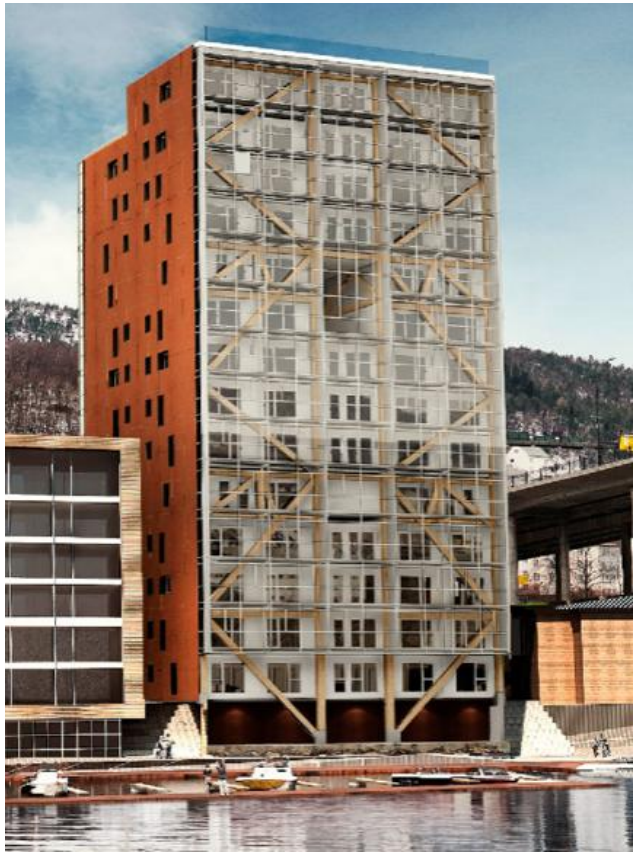
(Will Pryce)

9-storey, Murray Grove, London, 2009

(Victoria Harbour)

10-storey, Forté, Melbourne, 2012

6) Trends



(Malo K.A. et al 2016)

14-storey, Treet, Norway, 2015

(naturallywood.com)

18-storey, Brock Commons, Vancouver, 2017

University of Victoria

6) Trends

(newcivilengineer.com)

24-storey, HoHo, Vienna, under construction, 2018

(Sumitomo Forestry)

70-storey, W350, Japan, Proposed for 2041

1.3 Characteristics of Timber Structures

1) Advantages — Green Building

- Wood is renewable material

CWC

Sustainable forestry harvesting

TimberWest

A total of 5.35 million native species planted on Vancouver Island in TimberWest's spring 2015 planting season

1) Advantages — Green Building

- Green and environmentally friendly

(remove carbon from the atmosphere)

Example: embodied effects of a single family home (CWC report [2])

Relative to the **wood** design, the **steel** and **concrete** designs

• Energy:	26%	57%
• Greenhouse gas:	34%	81%
• Air pollution:	24%	47%
• Water pollution:	4 times	3.5 times
• Resources:	11%	81%
• Solid waste:	8%	23%

1) Advantages — Structure

- Light weight

	Average building weight [3]
Timber	1.9-2.4 kN/m^2
Steel framed	2.9-3.6 kN/m^2
Reinforced concrete	5.3-6.2 kN/m^2

- Higher strength to weight ratio
- Good seismic performance
  - Structural redundancy
  - Deformation
  - Energy dissipation

1) Advantages

- Modular and offsite construction

Stora Enso

A timber school for Vienna - with CLT

bonestructure.ca

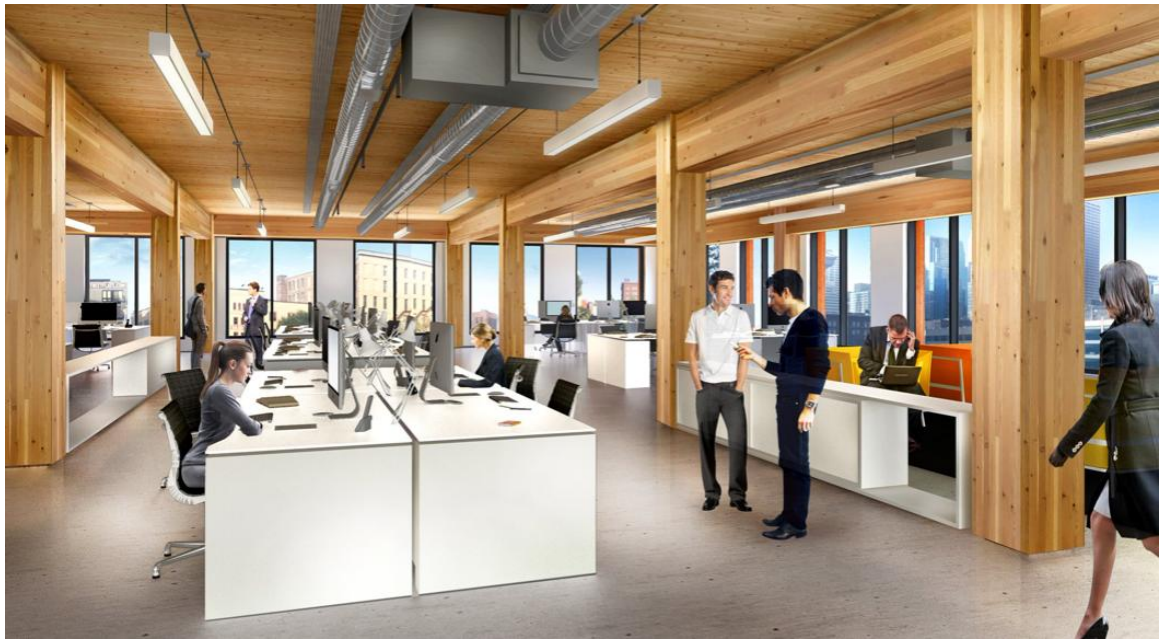
A light wood frame building

- Fast construction
- Quality control

1) Advantages

- Aesthetic benefit

Nordic



structurecraft.com

2) Challenges — Fire

- Timber is a combustible material

Light wood frame

Gregory Havel

Gypsum drywall board firebreak

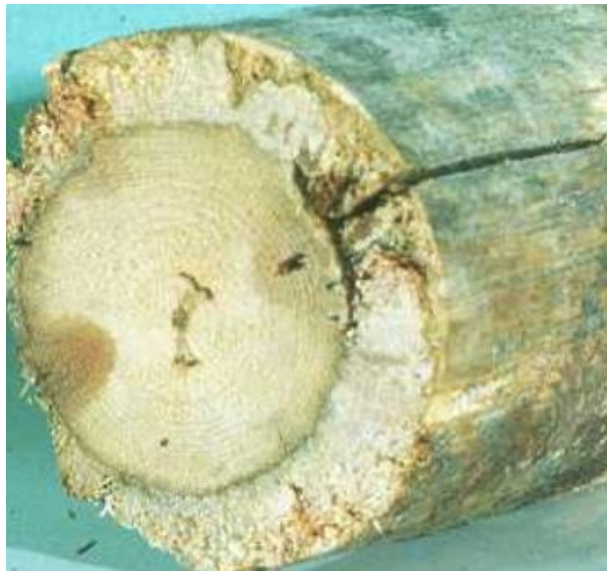
Mass timber

R.H. White and F.E. Woeste

Char layer

2) Challenges — Durability

- Wood is biodegradable



CWC

Decay

Bossheds

Sturdi-Wall Brackets

- Details example: timber separated from concrete

- Moisture control

2) Challenges — Durability

- Wood is biodegradable

CWC

Termites

CWC

Attached by termites

<u>Integrated control: The 6Ss</u>

- Suppression
- Site management
- Soil barrier
- Slab/foundation details
- Structural durability
- Surveillance and remediation

(http://cwc.ca/wp-content/uploads/controllingtermites-TermiteControlThe6Ss.pdf)

2) Challenges — Vibration and acoustic

- Composite timber and concrete floor

Ryan Rendano

Top: Poured concrete
Middle: Rigid foam board insulation
Base: CLT structural floor system

- Less susceptible to vibration
- Better acoustic separation
- Stiffer

2) Challenges — Moisture content

- Timber shrinks and swells with changes of moisture content

https://inspectapedia.com/structure/Beam_Log_Checking_Cracks.php

Checking

- Caused by moisture loss in the outer fibers
- Usually has minimal effect on the strength
- Needs to be evaluated

References

[1] Kuklik, P. 2008. *History of timber structures.* Leonardo da Vinci Pilot Project, CZ/06/B/F/PP/168007, Educational materials for designing and testing of timber structures. Czech Technical University in Prague, Prague, Czech Republic.

[2] Canadian Wood Council (CWC). *Energy and the environment in residential construction*. Ottawa, ON, Canada. http://cwc.ca/wp-content/uploads/publications-Energy-and-the-Environment.pdf

[3] Hibbeler R.C. 2018. *Structural analysis*. Pearson Education, Inc. Hoboken, NJ, USA.