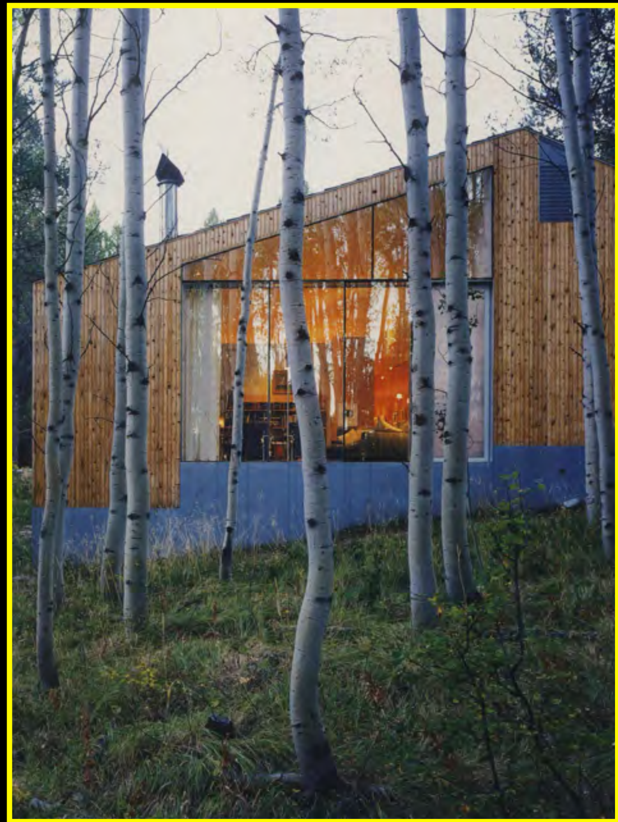
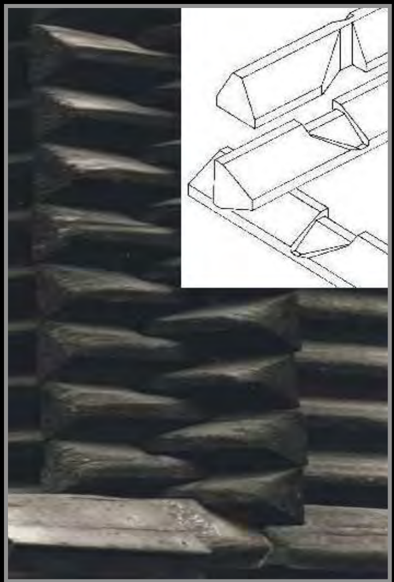
Construction Technology 1 (ARCH 24501)

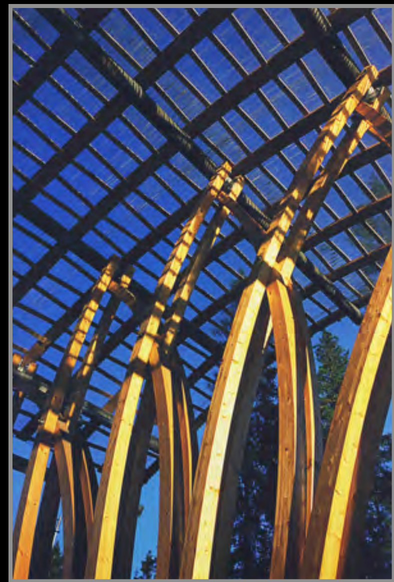
Intro to Basic Materials:



WOOD MATERIALS



MATERIAL KNOW-HOW



NATURE, FUEL, FURNITURE, BUILDING MATERIAL,…

VARIETY: COLOR, GRAIN, SCENTS,…

85 Rondelet's interpretation of Vitruv's description of the beginnings of timber ; of timber construction. (source: Rondelet, 1833, Pl. LXXI, Fig. 2)




MATERIAL	EMBODIED ENERGY MJ/kg	EMBODIED ENERGY MJ/m3
Stone (local)	0.79	2030
Concrete block	0.94	2350
Concrete (30 Mpa)	1.3	3180
Lumber	2.5	1380
Brick	2.5	5170
Cellulose insulation	3.3	112
Gypsum wallboard	6.1	5890
Particle board	8.0	4400
Aluminum (recycled)	8.1	21870
Steel (recycled)	8.9	37210
Shingles (asphalt)	9.0	4930
Plywood	10.4	5720
Mineral wool insulation	14.6	139
Glass	15.9	37550
Fiberglass insulation	30.3	970
Steel	32.0	251200
PVC	70.0	93620
Copper	70.6	631164
Paint	93.3	117500
Polystyrene Insulation	117	3770
Aluminum	227	515700

PG. 79 COURSE BOOK: "A RECENT CANADIAN STUDY OF THE ENTIRE LIFE CYCLE COST OF A SMALL OFFICE BUILDING COMPARES SIMILAR BUILDINGS FRAMED WITH WOOD, STEEL AND CONCRETE. THE TOTAL ENERGY USED FOR THE WOOD BUILDING IS ABOUT $^{1}/_{2}$ OF THAT FOR THE STEEL BUILDING AND $^{2}/_{3}$ OF THAT FOR THE CONCRETE BUILDING...

THE MATERIAL: “STORAGE OF SOLAR ENERGY”

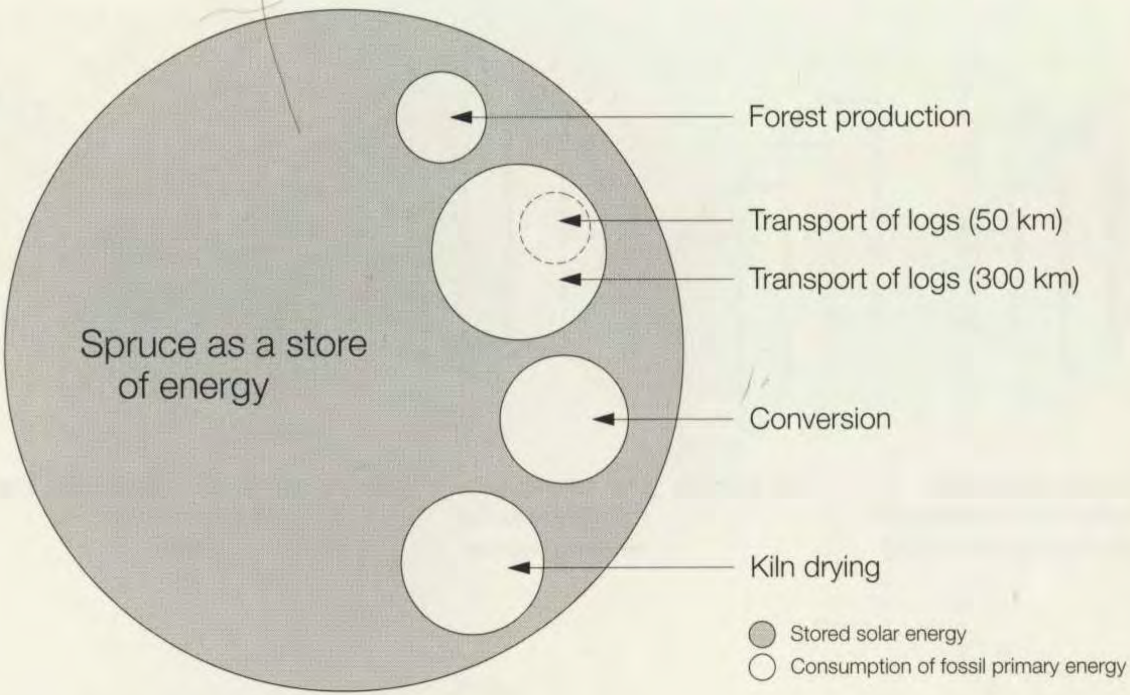


Fig. 6: Energy balance for the production of dried softwood sawn timber
(white circles: fossil energy requirement in comparison to the energy stored in the wood)

Source: ‘Energy Manual’, Hegger, Fuchs, Stark, Zeumer; Publ.: Birkhäuser 2008

THE MATERIAL: "STORAGE OF CARBON DIOXIDE"

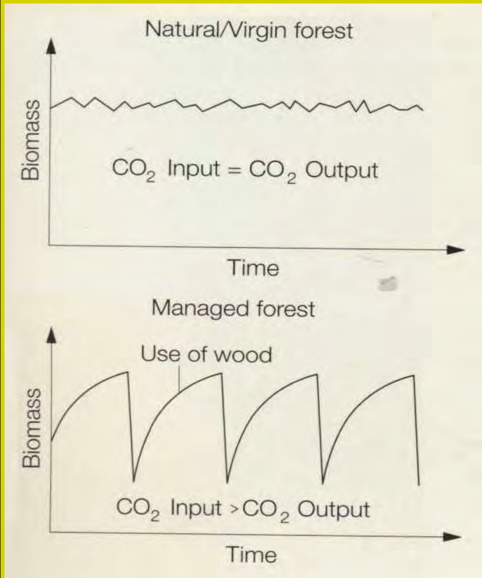


Fig. 3: Total life cycle of timber, which corresponds to the carbon dioxide cycle

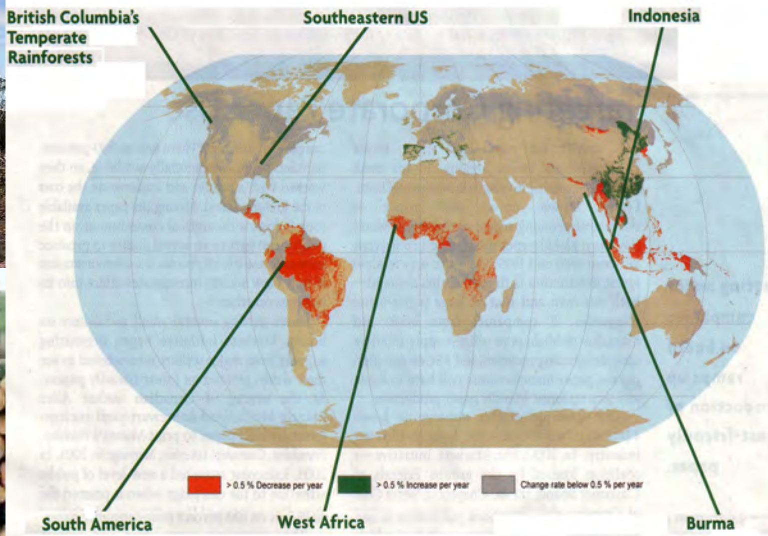
FORESTRY MANAGEMENT / DEFORESTATION

HOW BAD IS THE DEFORESTATION PROBLEM?

With the exceptions of China, Cuba, and some European countries, every forested country on the planet is losing forest area.

Globally, we lose more than 32 million acres every year to agriculture, development, resource extraction, and the manufacture of wood and paper products.

But we need to take more action quickly; even at this rate, a child born today would see the worldwide loss of 900 million acres of forest—an area larger than all of America's forests combined—by the time she's 50.



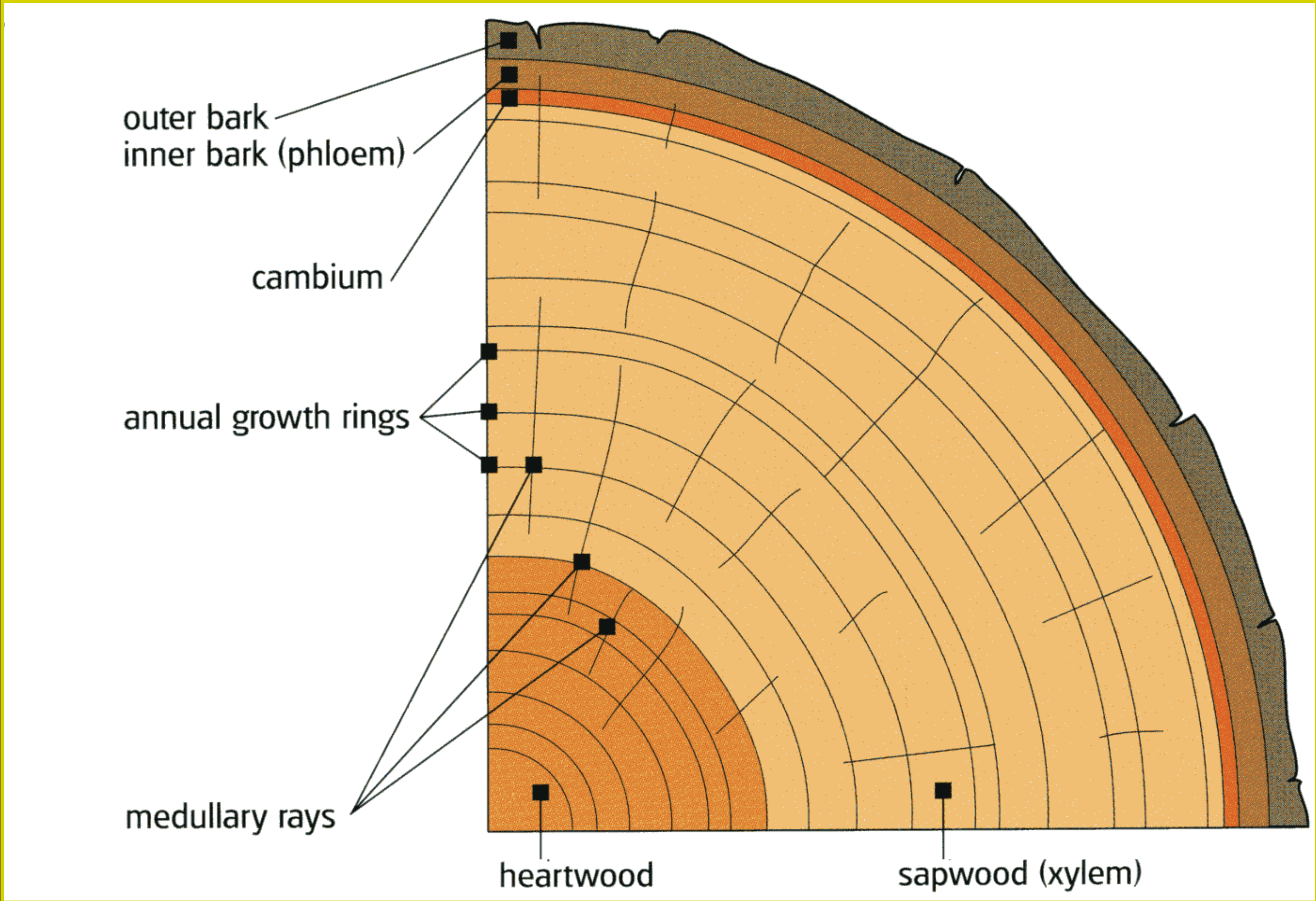
www.sfiprogram.org (see course book, pg.111)

“SUSTAINABILITY”

- Wood is a **Natural Resource**
- Wood is a **renewable** Resource
- Wood **deposits CO_2**
- Wood is easily **transportable**
- Wood might be obtained **locally**
- Wood is **low** in Embodied Energy
- Wood is easily **recyclable**
- Wood is relatively **economical**
- Wood needs **Reforesting Mgmt.**

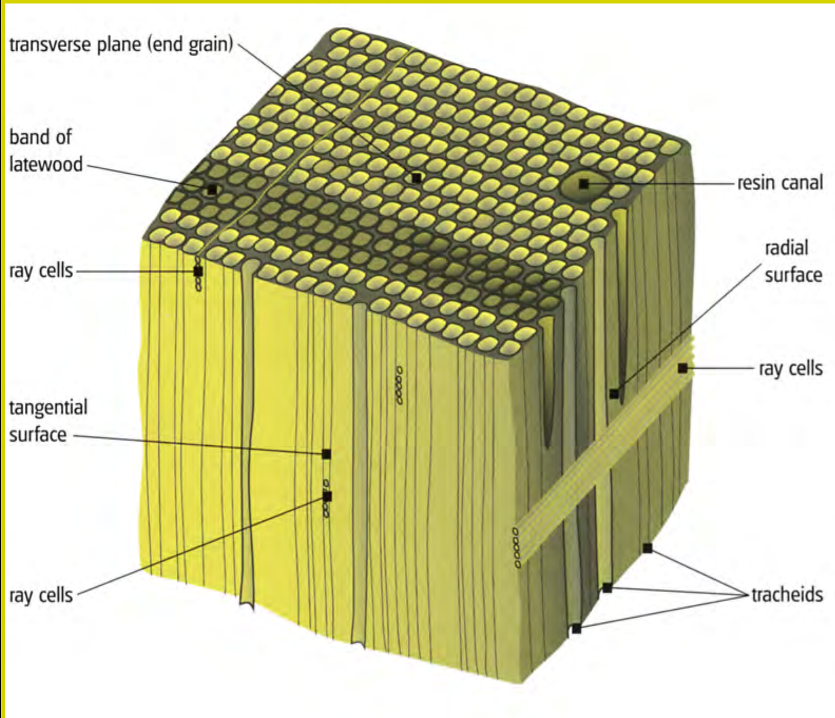
UNDERSTANDING THE TREE ‘PHYSIOLOGY’

MATERIALIZED MEASURE OF TIME: ‘YEAR RING’ : SPRINGWOOD + SUMMERWOOD


outer bark
inner bark (phloem)
cambium
annual growth rings
medullary rays
heartwood
sapwood (xylem)

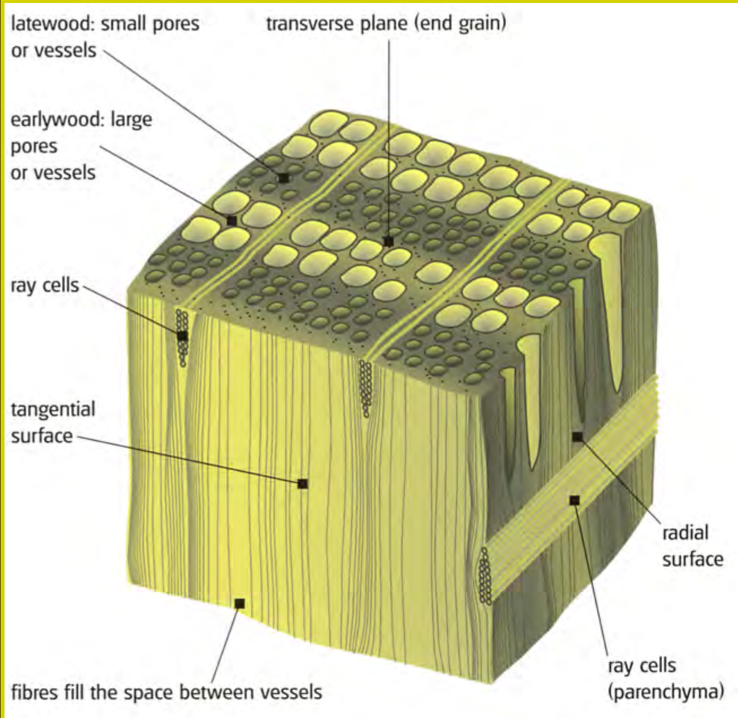
THE MATERIAL: **“SOFTWOOD”**

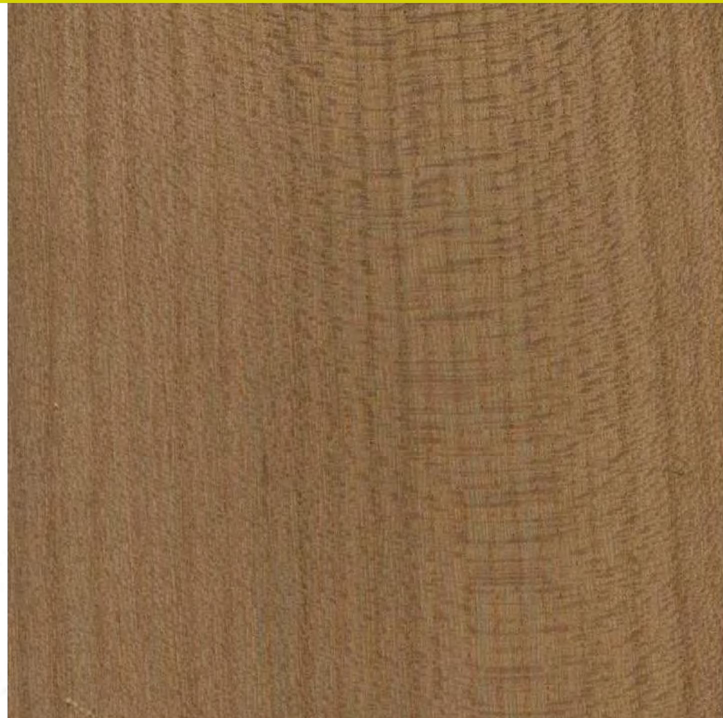
→ CONIFEROUS TREES



THE MATERIAL: "HARDWOOD"

→ DECIDIOUS TREES





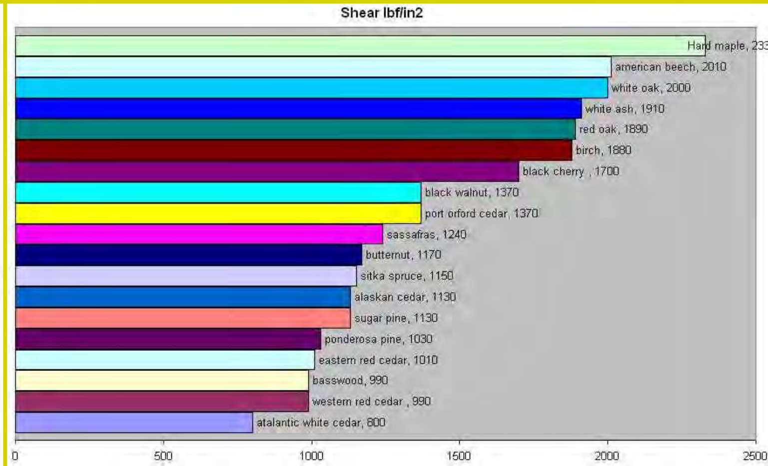
“SOFTWOOD”

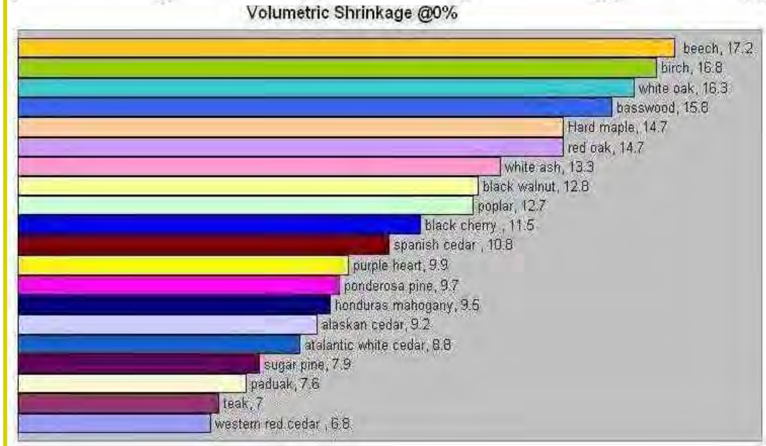
SPRUCE, DOUGLAS FIR, PINE, LARCH, …

“HARDWOOD”

MAPLE, OAK, CHERRY, WALNUT, EBONY, …

PROPERTIES: … SHEAR STRENGTH, SHRINKAGE,… ETC.





…DECAY RESITANCE: CEDAR, CYPRESS, REDWOOD, TEAK,…

PROPERTIES OF STRUCTURAL SOFTWOODS: (GRAIN)

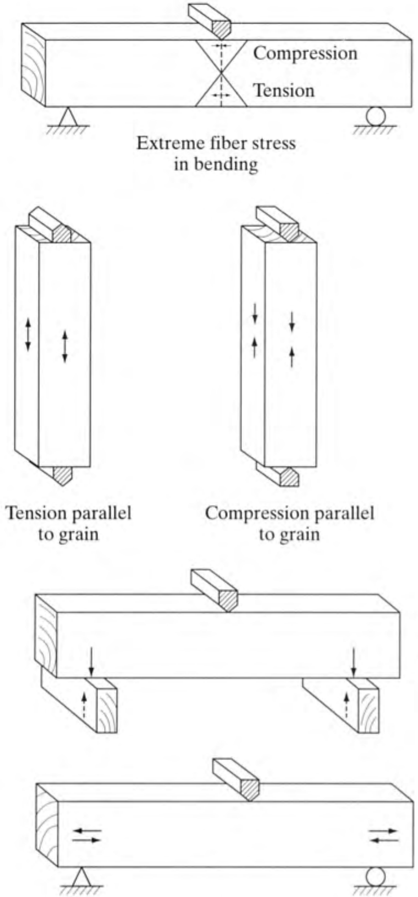


TABLE 5.6 AVERAGE MECHANICAL PROPERTIES OF SOME COMMON SOFTWOODS[a]

Species	Modulus of rupture (psi)	Modulus of elasticity (psi $\times 10^6$)	Compression parallel to grain (psi)	Compression perpendicular to grain (psi)	Tension parallel to grain (psi)	Tension perpendicular to grain (psi)
Northern White Cedar	6500	0.8	4000	310	—	240
Western Red Cedar	7500	1.1	4500	460	8600	220
Douglas Fir	12,500	1.5–1.8	6200–7200	750	20,000	350
Hemlock	6500–12,000	1.2–1.6	5500–7200	550–850	17,000	350
Western Larch	13,000	1.85	7500	930	21,000	430
Ponderosa Pine	9400	1.30	5300	580	11,000	420
Virginia Pine	13,000	1.52	6700	910	17,500	380
Redwood	8000–10,000	1.1–1.3	5200–6200	500–700	12,000	250
Sitka Spruce	10,000	1.5	5600	580	11,000	370

[a]Based on clear wood tests at 12 percent moisture content.

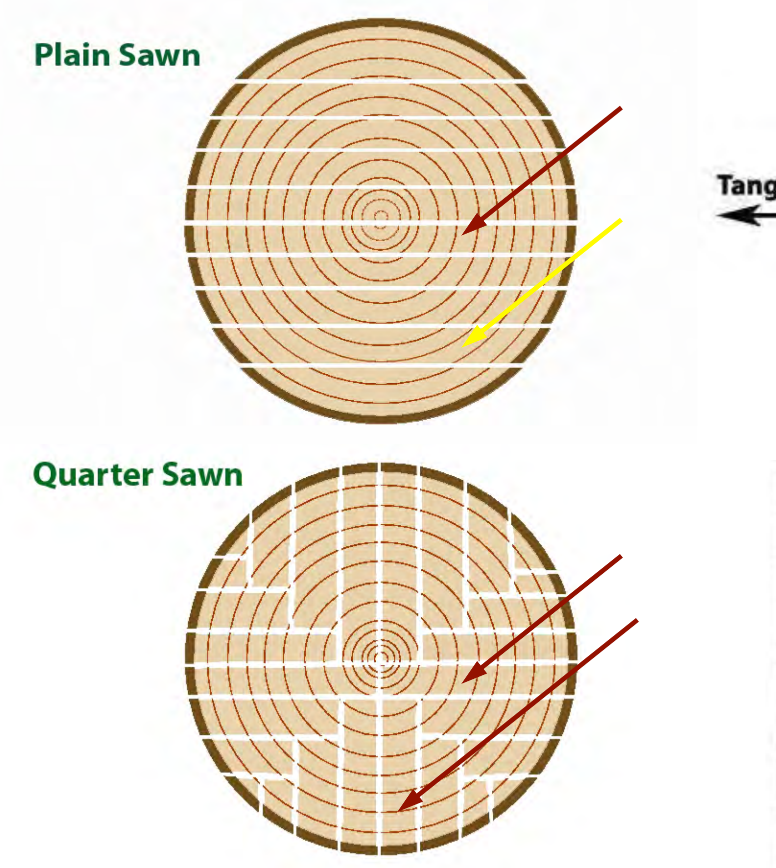
MATERIAL PROPERTIES: (COMPARISON)

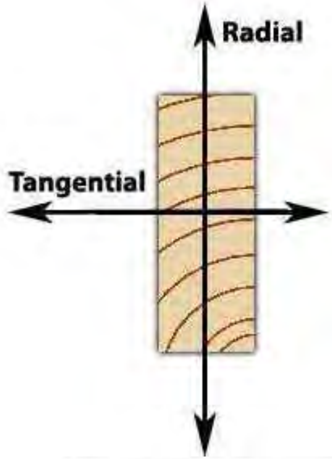
Material	Allowable Tensile Strength	Allowable Compressive Strength	Density	Modulus of Elasticity
Wood (average)	700 psi (4.83 MPa)	1,100 psi (7.58 MPa)	30 pcf (480 kg/m^3)	1,200,000 psi (8,275 MPa)
Brick masonry (average)	0	250 psi (1.72 MPa)	120 pcf (1,920 kg/m^3)	1,200,000 psi (8,275 MPa)
Steel (ASTM A36)	22,000 psi (151.69 MPa)	22,000 psi (151.69 MPa)	490 pcf (7,850 kg/m^3)	29,000,000 psi (200,000 MPa)
Concrete (average)	0	1,350 psi (9.31 MPa)	145 pcf (2,320 kg/m^3)	3,150,000 psi (21,720 MPa)

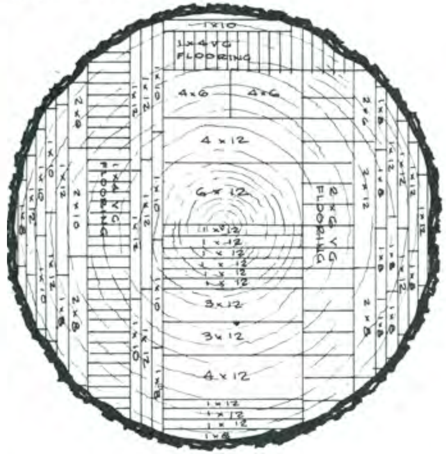



FABRICATION:

FABRICATION: "PLAIN SAWN / QUARTER SAWN"



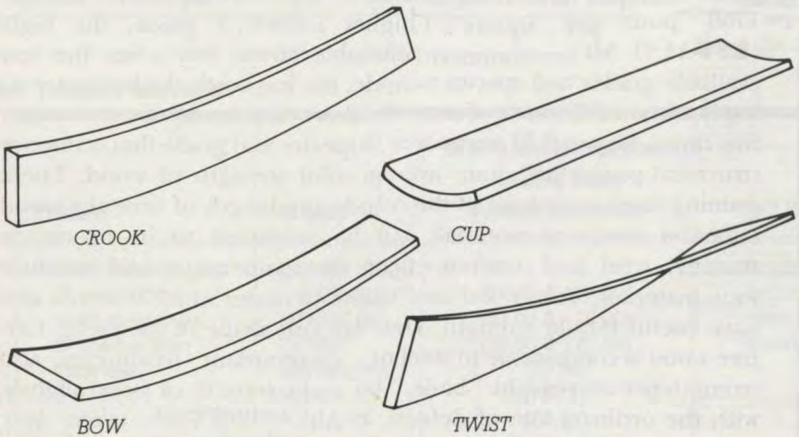


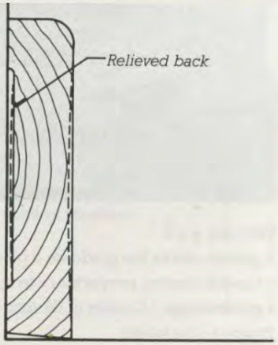


TANGENTIAL SHRINKAGE … GREATER THAN **RADIAL** … GREATER THAN **LONGITUDINAL**

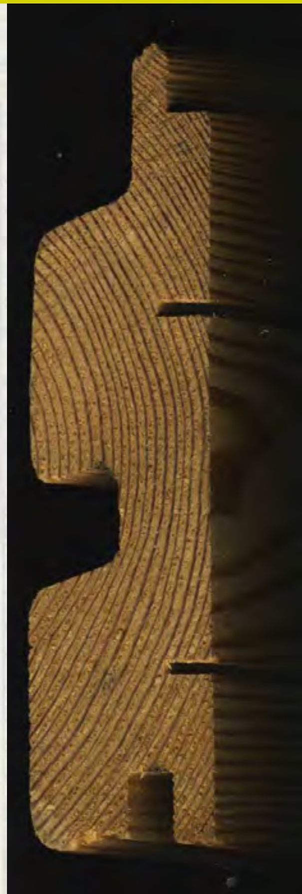
FABRICATION: "SEASONING DISTORTION"

Four types of seasoning distortions in dimension lumber.

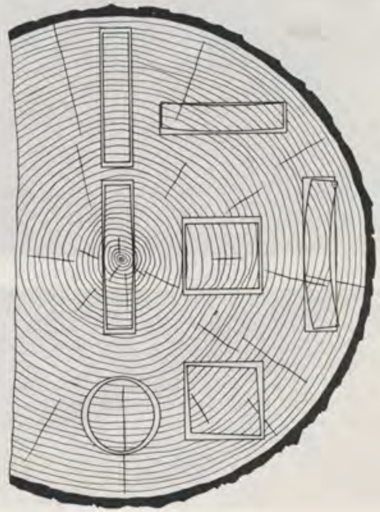




The wood baseboard, seen in cross section, has been formed with a relieved back, a broad, shallow groove that allows the piece to lie flat against the wall even if it cups (broken lines). The sloping bottom on the baseboard assures that it can be installed tightly against the floor despite the cup. The grain orientation in this piece is the worst possible with respect to cupping.



The difference between tangential and radial shrinkage also produces seasoning distortions in lumber. The nature of the distortion depends on the position the piece of lumber occupied in the tree. The distortions are the most pronounced in plain-sawed lumber (upper right, extreme right, lower right). (*Courtesy of Forest Products Laboratory, Forest Service, USDA*)



FABRICATION: "KILN DRYING" (MOISTURE REMOVAL)

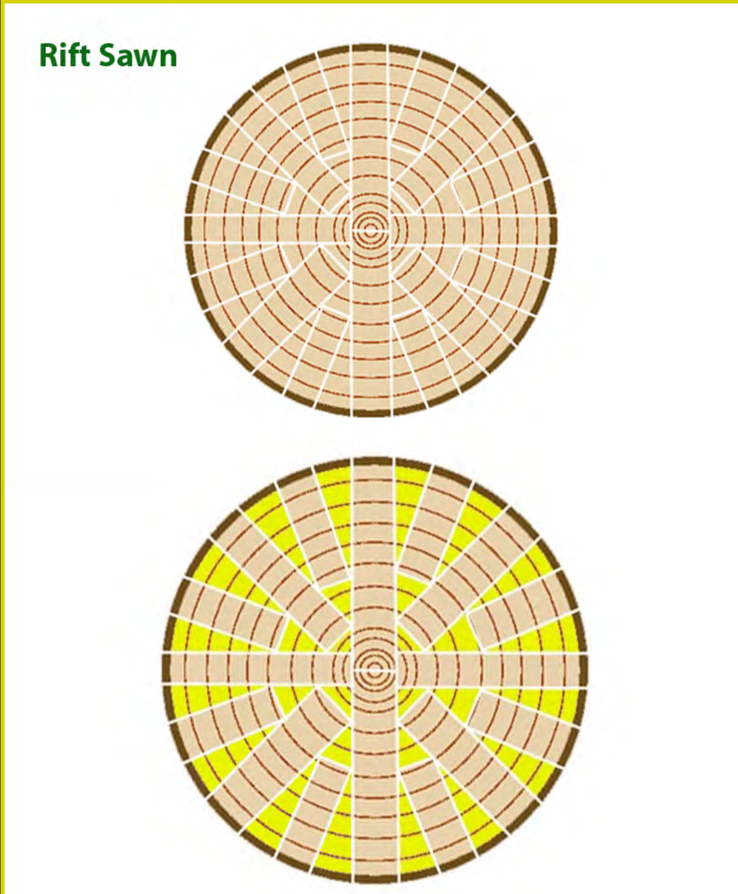
MOISTURE CONTENT:

ORIGINAL STATE: UP TO 300%
(OF OVEN-DRY WEIGHT)

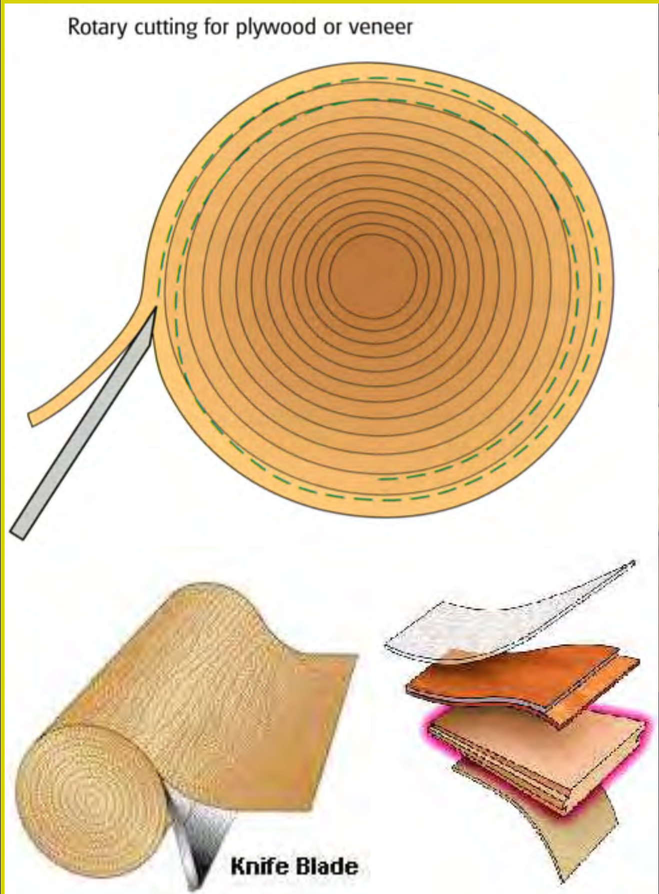
'GREEN WOOD' : ~ 30%

'SEASONED WOOD' : 19 % - 13 %

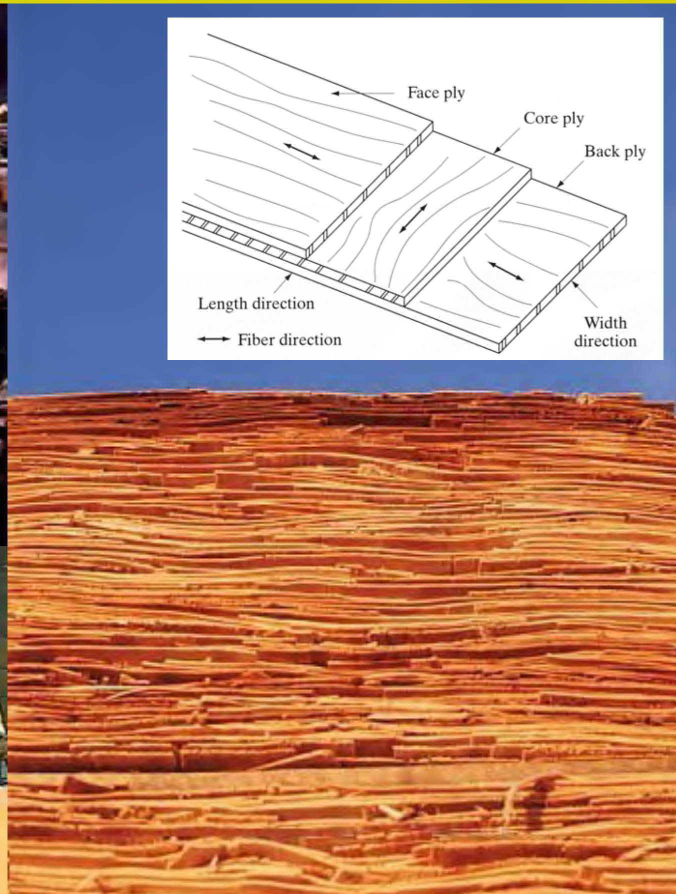
FABRICATION: "RIFT SAWN"



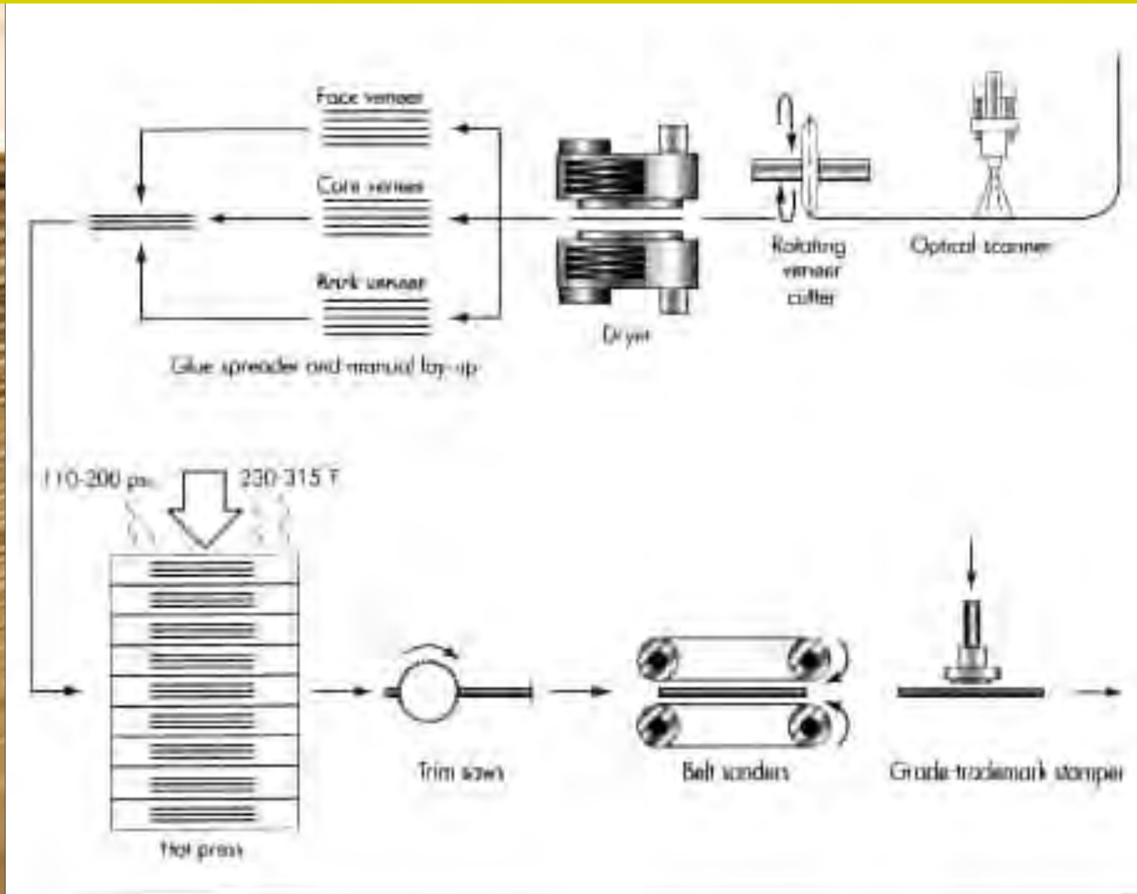
FABRICATION: "ROTARY CUT"



FABRICATION: LAMINATION: PLYWOOD



FABRICATION: LAMINATION: PLYWOOD

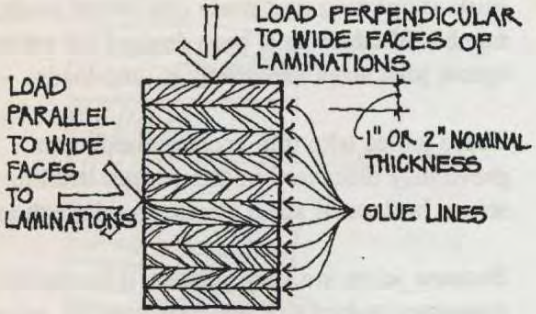


SHEET MATERIAL:

FABRICATION: "LAMINATION"

'GLULAM'

Number of Laminations	1" Nominal Laminations	2" Nominal Laminations
4	3"	6"
5	3-3/4"	7-1/2"
6	4-1/2"	9"
etc.	etc.	etc.



CROSS-SECTION OF GLUED LAMINATED MEMBER

FABRICATION: "LAMINATION"

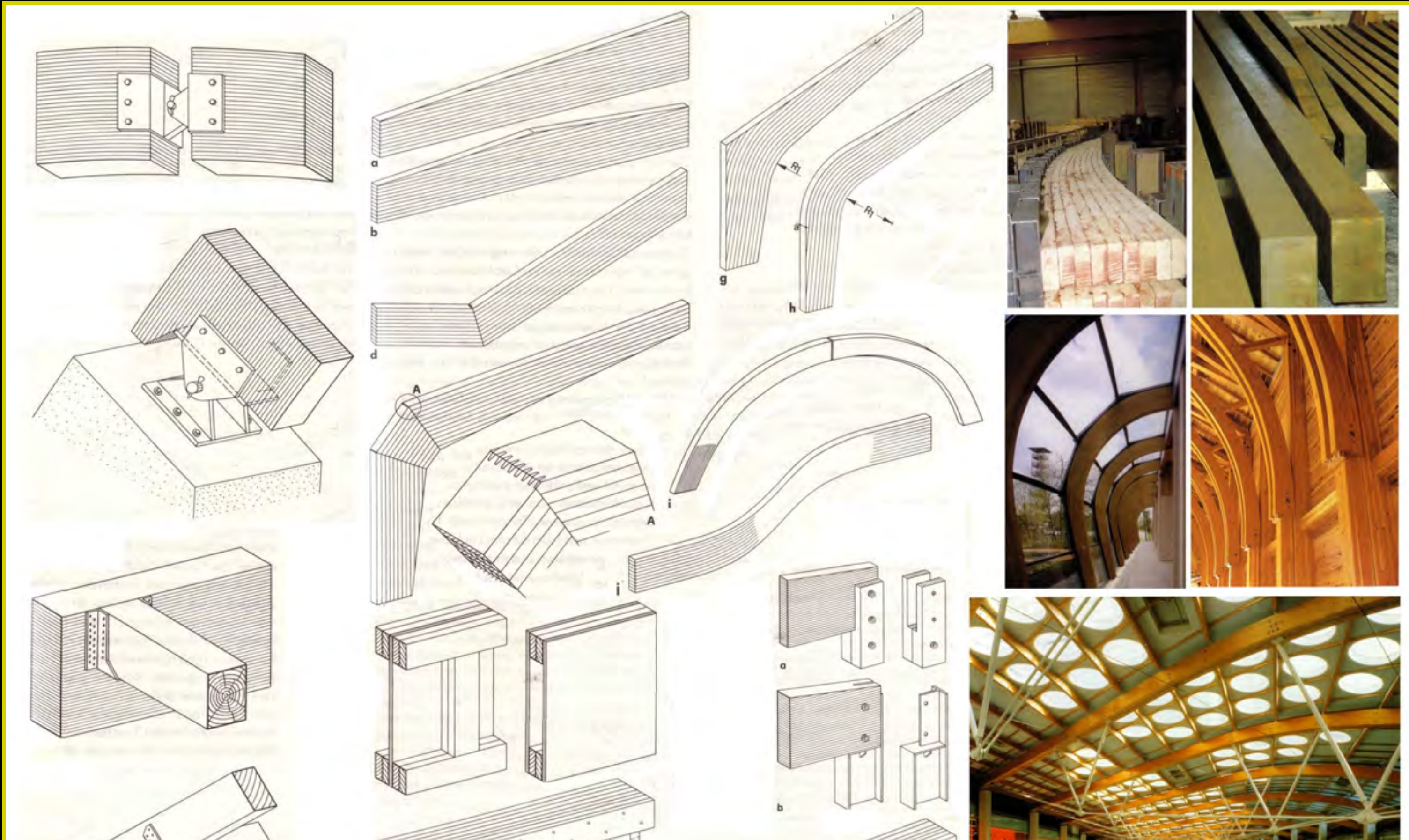
'GLULAM'

"ENGINEERED LUMBER"

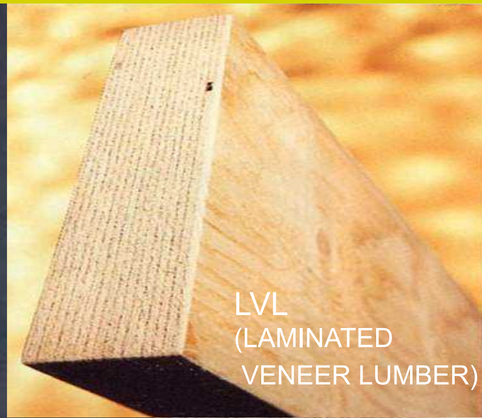
- **Eliminated Defects**
- **Engineered Strength**
- **Use of smaller Lumber**
- **Recycled Products**
- **Form Versatility**

FABRICATION: "LAMINATION"

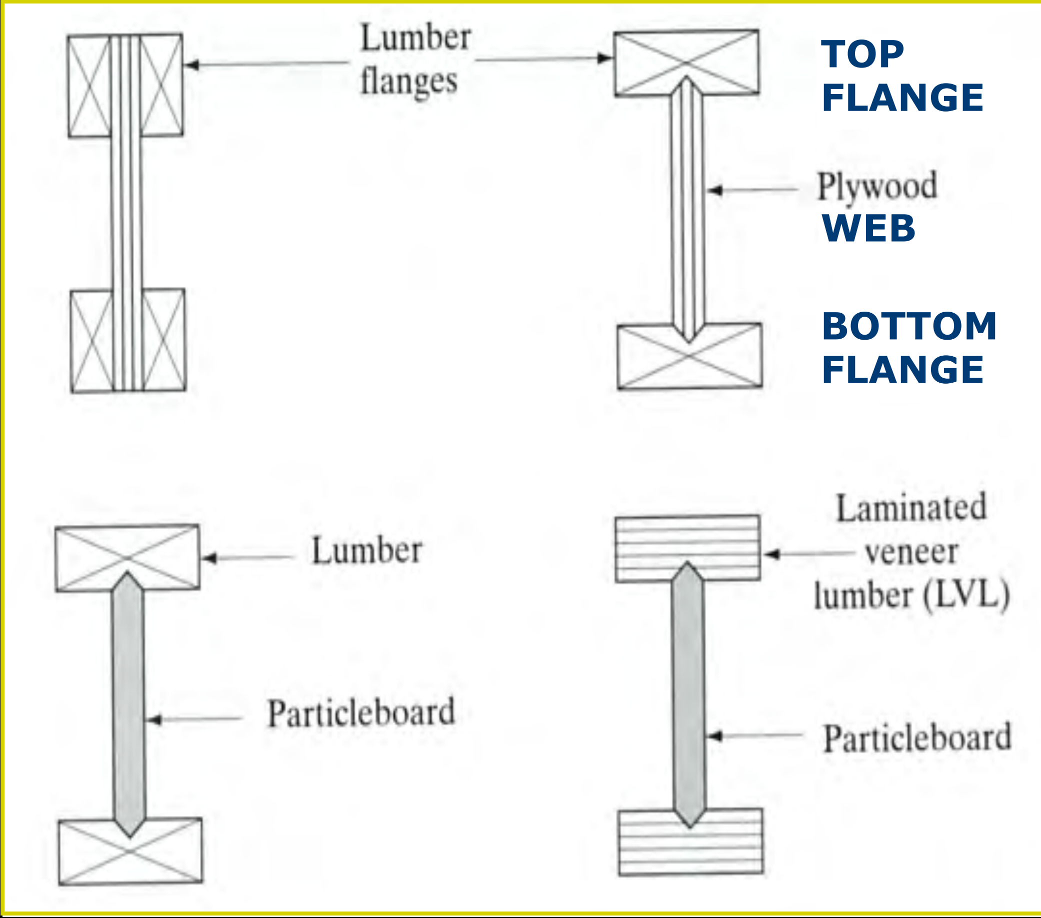
'GLULAM'



MORE ENGINEERED LUMBER: ‘LVL’ ‘LSL’

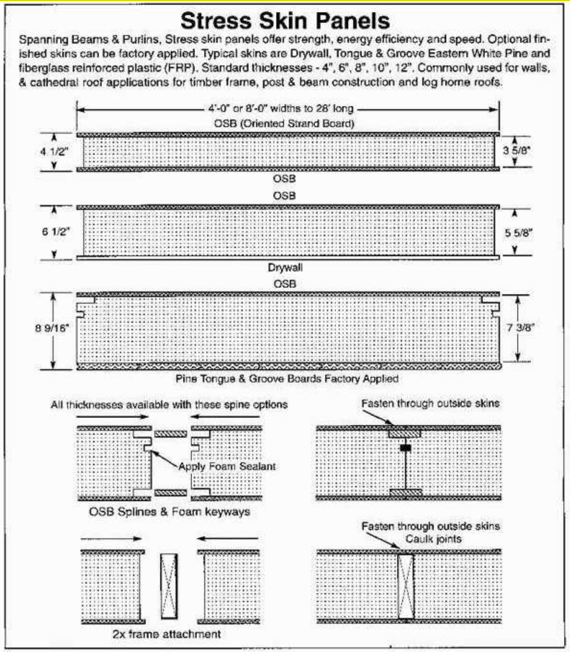


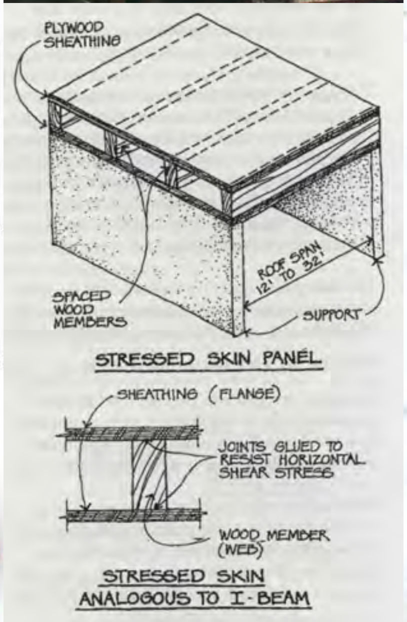
MORE ENGINEERED LUMBER: 'I - JOISTS'

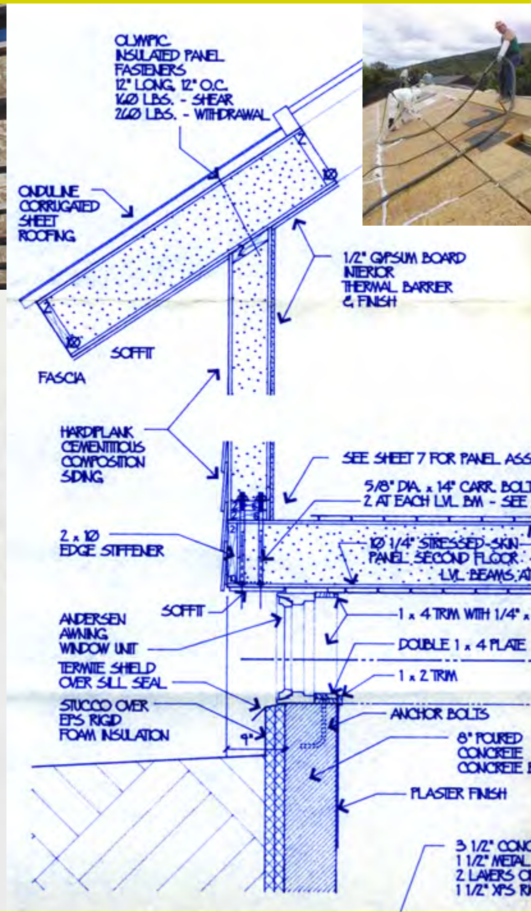


LAMINATION: “COMPOSITES”

‘SSP’ , ‘SIP’

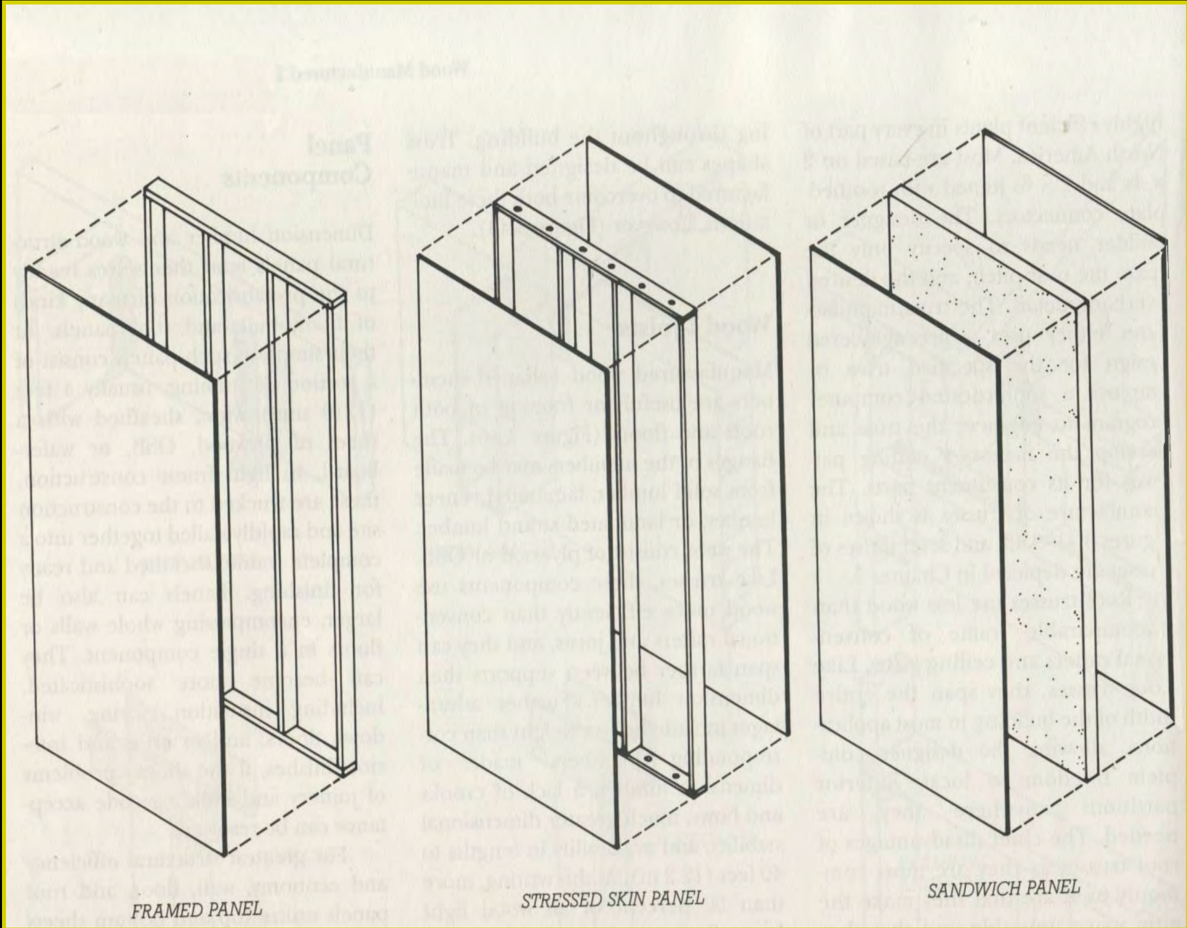


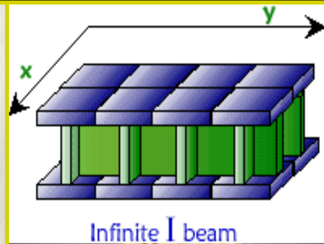




"STRESSED SKIN PANELS"

'SSP' , 'SIP'





FABRICATION: “DEFORMATION”

Pour donner une certaine forme au bois, on peut évidemment le scier mais il existe un autre procédé consistant à le soumettre à une forte pression. A relativement peu de frais et sans pertes importantes de matériau, on peut fabriquer des poutres destinées à la construction à partir de petits bois de moins de 20 centimètres de diamètre, qui ne sont d'ordinaire que d'un très faible rapport. Cette image, tirée d'un projet d'études à l'EPF de Zurich, Chaire de technologie du bois, montre en haut le produit de départ et en bas la poutre obtenue. L'avantage de ce procédé réside notamment dans le fait que le bois est séché et mis en forme en une seule opération.

“CNC” / “CAM”

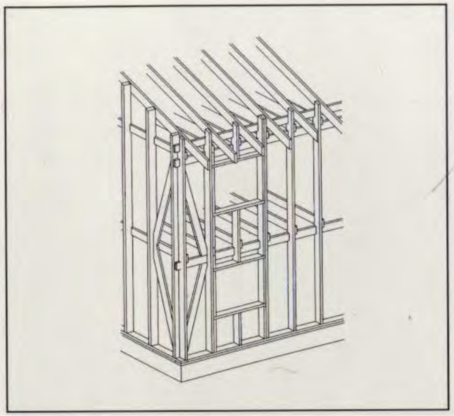
PRECISION JOINTS

CHARACTERISTICS: WOOD **(ORGANIC MATERIAL)**

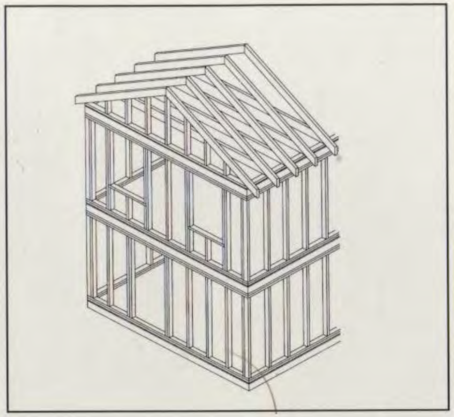
- COMBUSTIBLE
- SUSCEPTIBLE TO WEATHER + INSECTS
- ROTS, DECAYS (BIODEGRADABLE)
- LIGHTEST OF ALL STRUCTURAL MATERIALS
- CAPABLE OF LOADING IN BOTH TENSION AND COMPRESSION
- PROCESSED IN DIFFERENT SCALES
- SOFT+WARM, RESIDENTIAL TOUCH

CHARACTERISTICS: WOOD **(ORGANIC MATERIAL)**

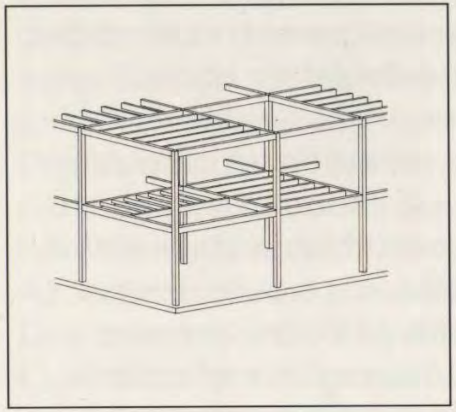
WOOD BUILDING TYPES:



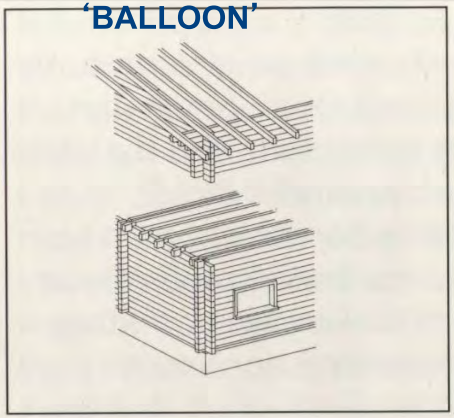
LIGHT FRAME: ‘BALLOON’



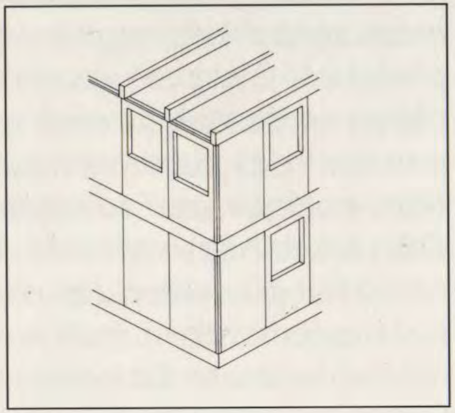
LIGHT FRAME: ‘PLATFORM’



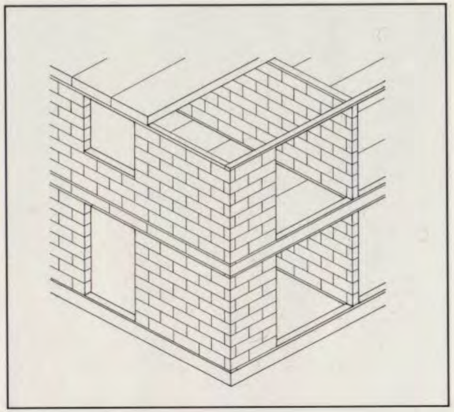
HEAVY TIMBER:’ POST+BEAM’



LOG CONSTRUCTION



PANELS / ‘STRESSED SKIN’



ELEMENTS / ‘MODULAR’

→ TYPOLOGY OF HUMAN PRODUCTION METHODS:

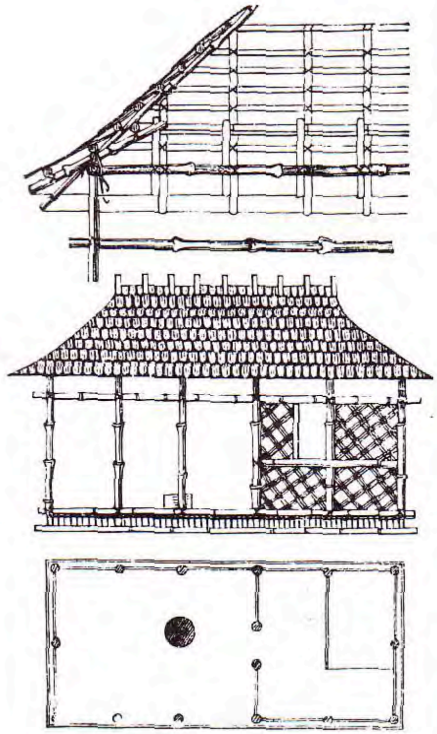
G.Semper:
"Style in the Technical and Tectonic Arts - or Practical Aesthetics" 1860

Four 'ORIGINAL' Methods of Production

- -WEAVING
- -POTTERY
- -TECTONICS → TIMBER CONSTRUCTION
- -STEREOTOMY → LOG CONSTRUCTION

"The 'KNOT' (as representation of a technical solution) is the oldest technical symbol and… the prime motif of human ***'tekhne'*** (craft, …roots of skill of building) *because a structural necessity (the connection of two elements) becomes an aesthetic, meaningful image."*

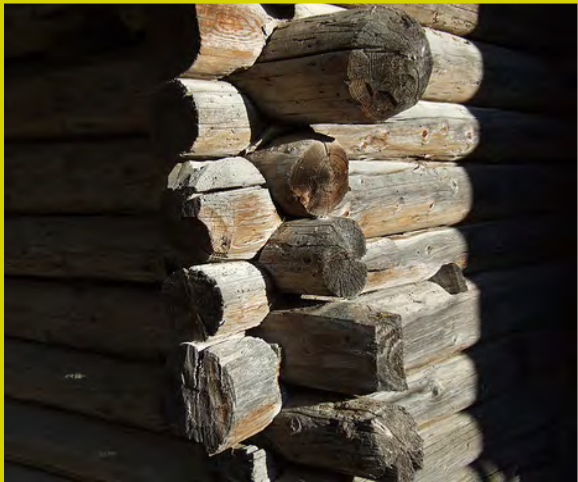
2.) … RELATIONSHIP: STRUCTURE ↔ SKIN …

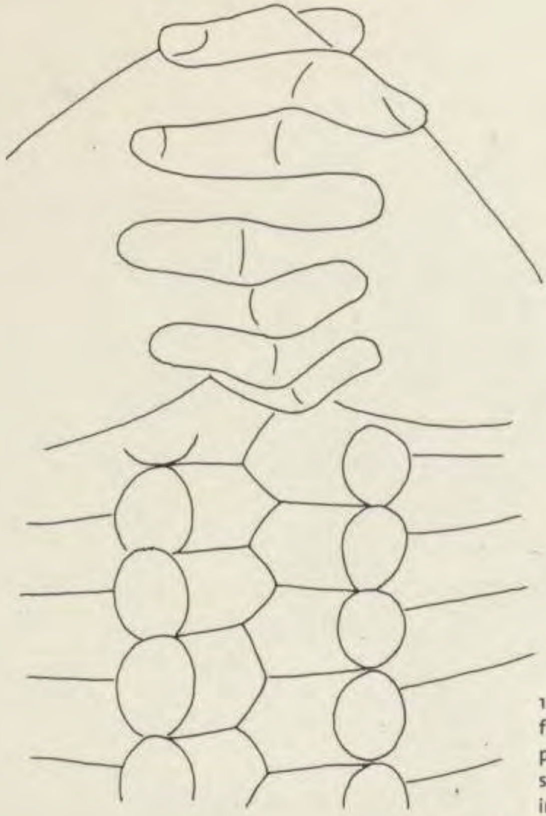


Gottfried Semper, illustration from *Der Stil in den technischen und tektonischen Künsten*, 1860–1863. The Caribbean hut in the Great Exhibition of 1851.

LOG CONSTRUCTION

…STEREOTOMY…

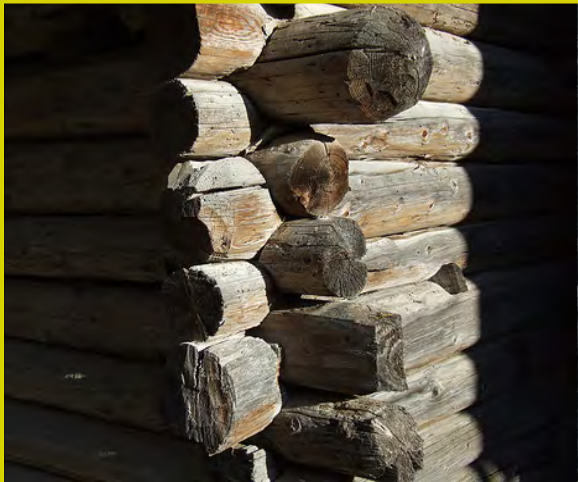


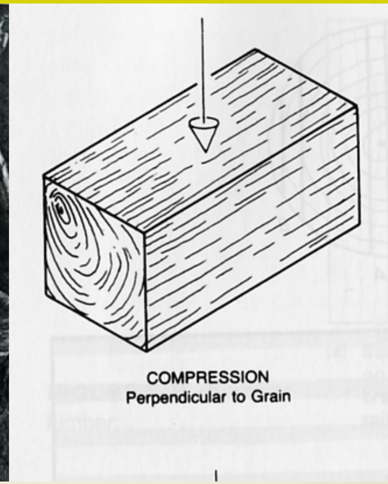


145 The likeness between interlocking fingers and log construction does indeed point to simplicity, but it also demonstrates the creation and separation of interior and exterior.

LOG CONSTRUCTION

…TECTONICS…





Log-wall Profiles

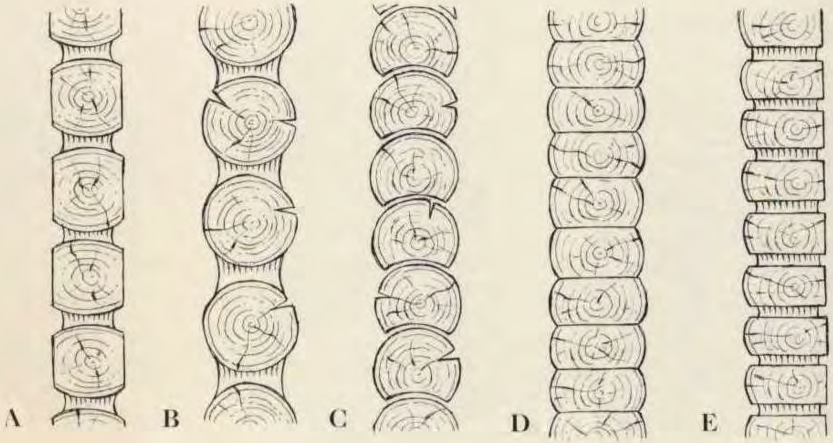
A. Chinked two-sided hewn logs stacked vertically

B. Chinked round logs

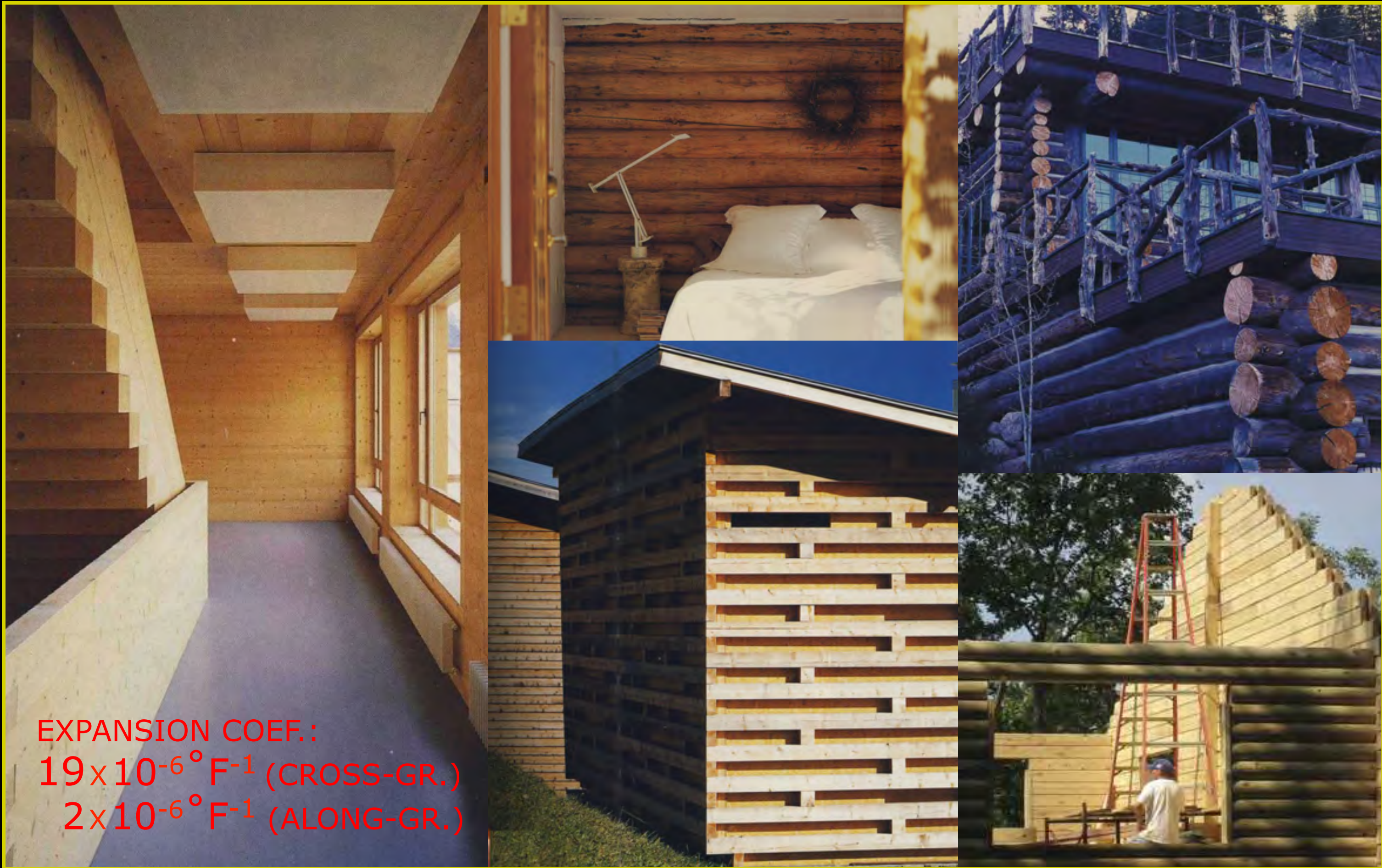
C. Scribed round logs

D. Chinkless two-sided hewn logs stacked flat

E. Chinked three-sided hewn logs stacked flat



LOG CONSTRUCTION



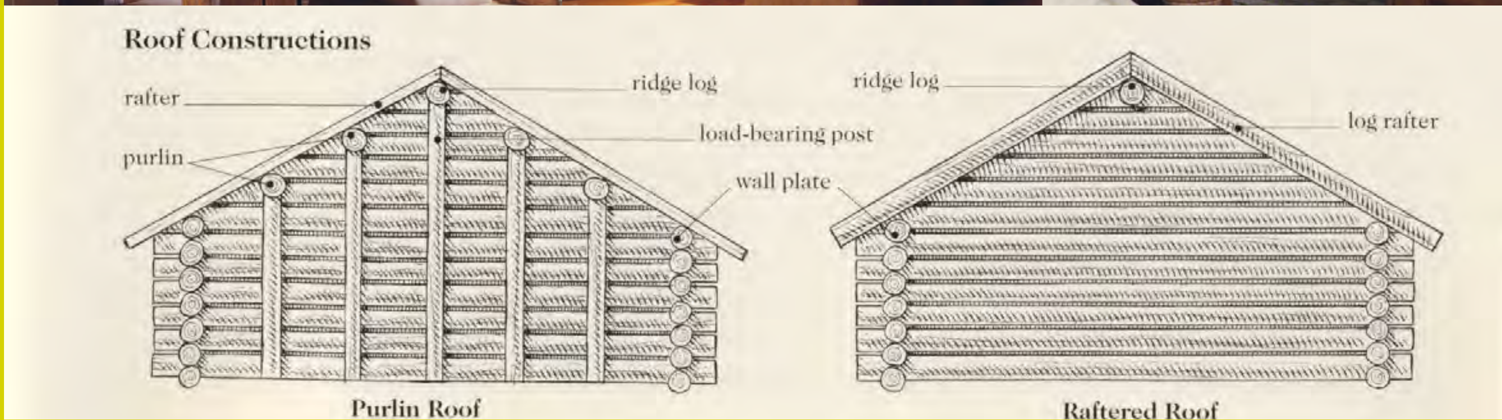
EXPANSION COEF.:

$19 \times 10^{-6}\,{}^{\circ}F^{-1}$ (CROSS-GR.)

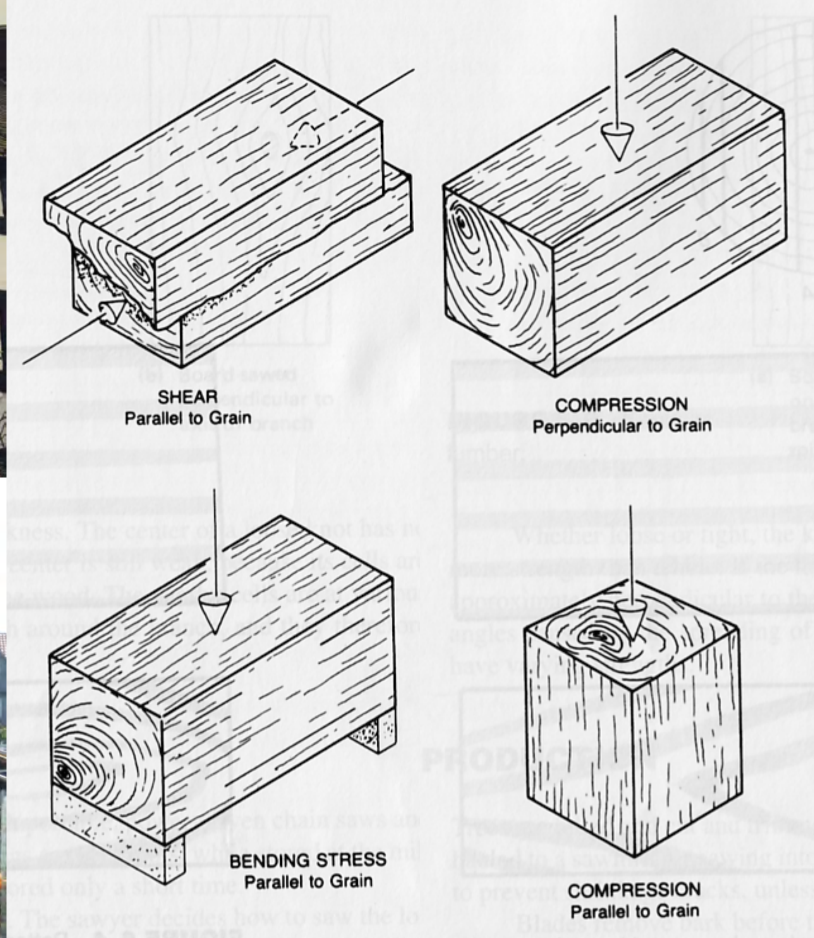
$2 \times 10^{-6}\,{}^{\circ}F^{-1}$ (ALONG-GR.)

LOG CONSTRUCTION

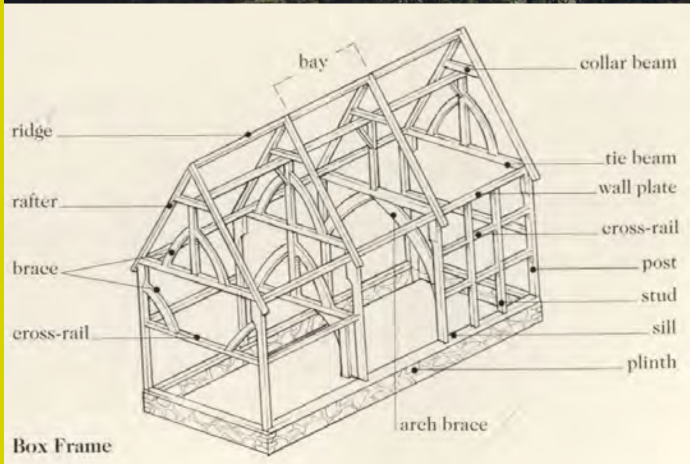
…TECTONICS…

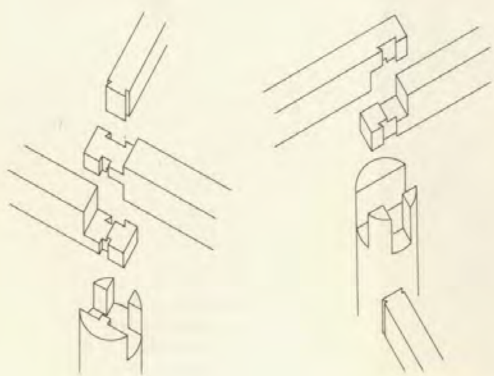


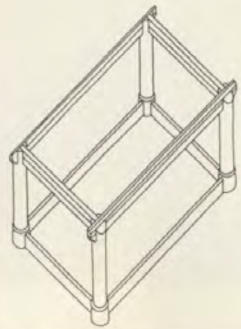
HALF-TIMBERED CONSTRUCTION …TECTONICS…



HALF-TIMBERED CONSTRUCTION (BOX FRAME)

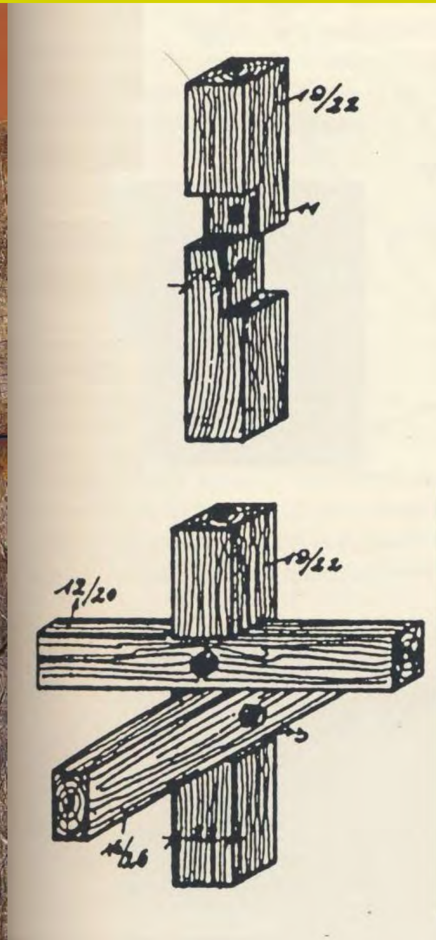




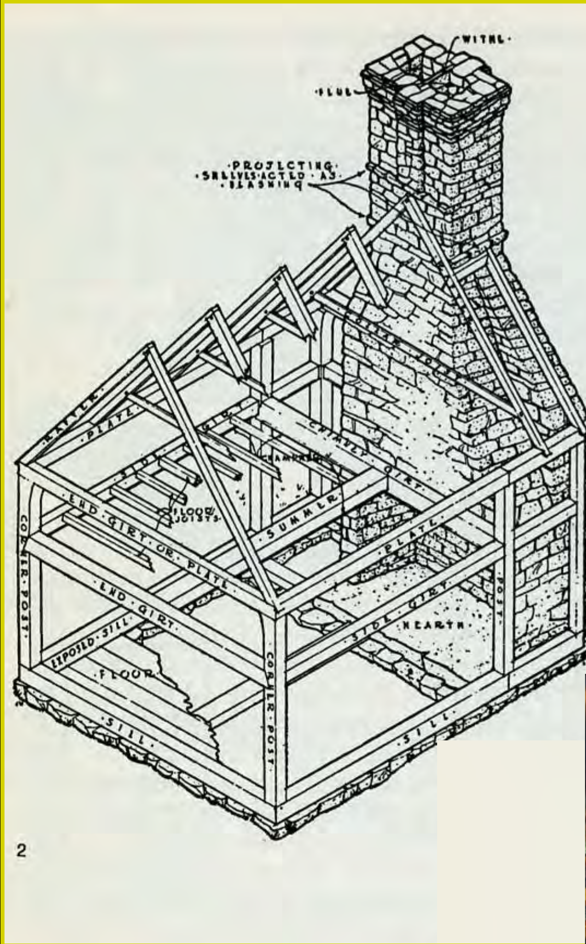


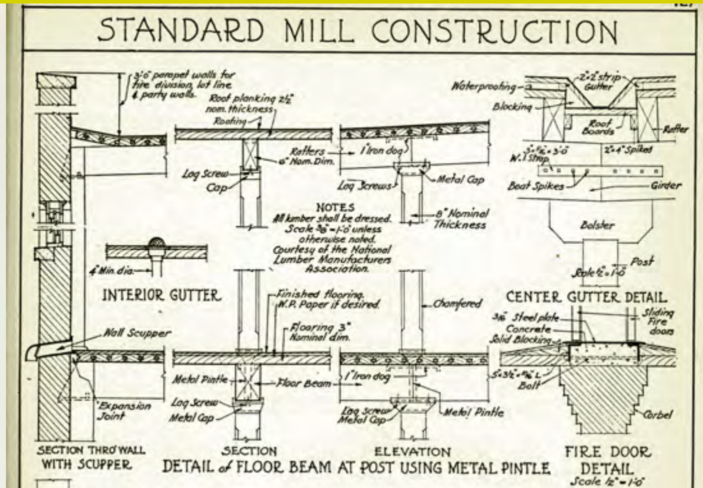
346 The principle of box-frame construction. (drawn by P. Pundt; source: ibid., Fig. 73) The rigidly connected members – sill beam, columns or posts, and header beam – form a frame on each side of the structure.

HALF-TIMBERED CONSTRUCTION (CONNECTION)



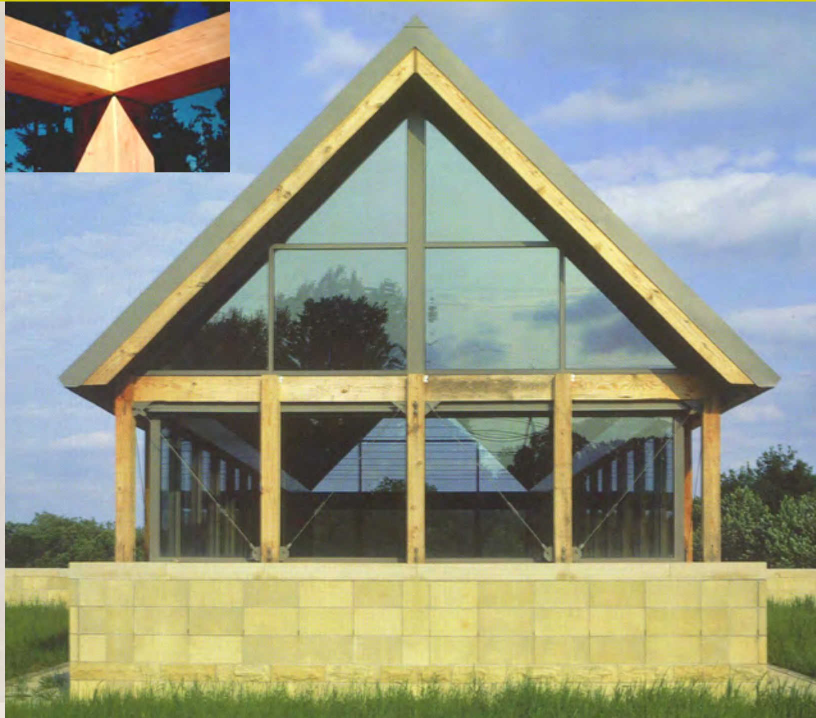
POST + BEAM CONSTRUCTION (HEAVY TIMBER, HT)





POST + BEAM CONSTRUCTION (HEAVY TIMBER, HT)

	Supporting Floor Loads	Supporting Roof and Ceiling Loads Only
Columns	8 × 8 (184 × 184 mm)	6 × 8 (140 × 184 mm)
Beams and Girders	6 × 10 (140 × 235 mm)	4 × 6 (89 × 140 mm)
Trusses	8 × 8 (184 × 184 mm)	4 × 6 (89 × 140 mm)
Decking	3″ + 1″ finish (64 mm + 19 mm finish)	2″, or 1⅛″ plywood (38 mm, or 29 mm plywood)

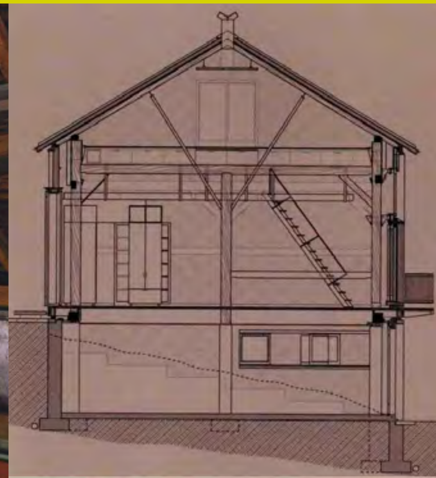
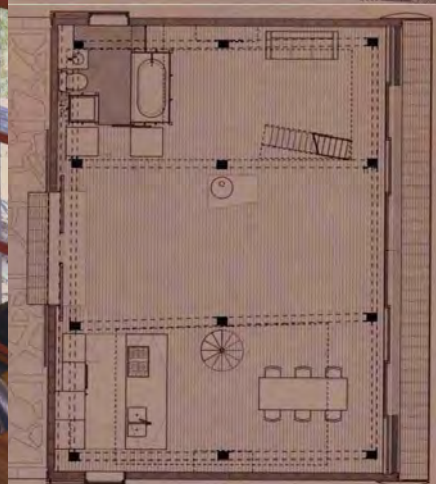


METAL PLATE FRAMING DEVICES

POST + BEAM CONSTRUCTION: STRUCTURE ↔ SKIN



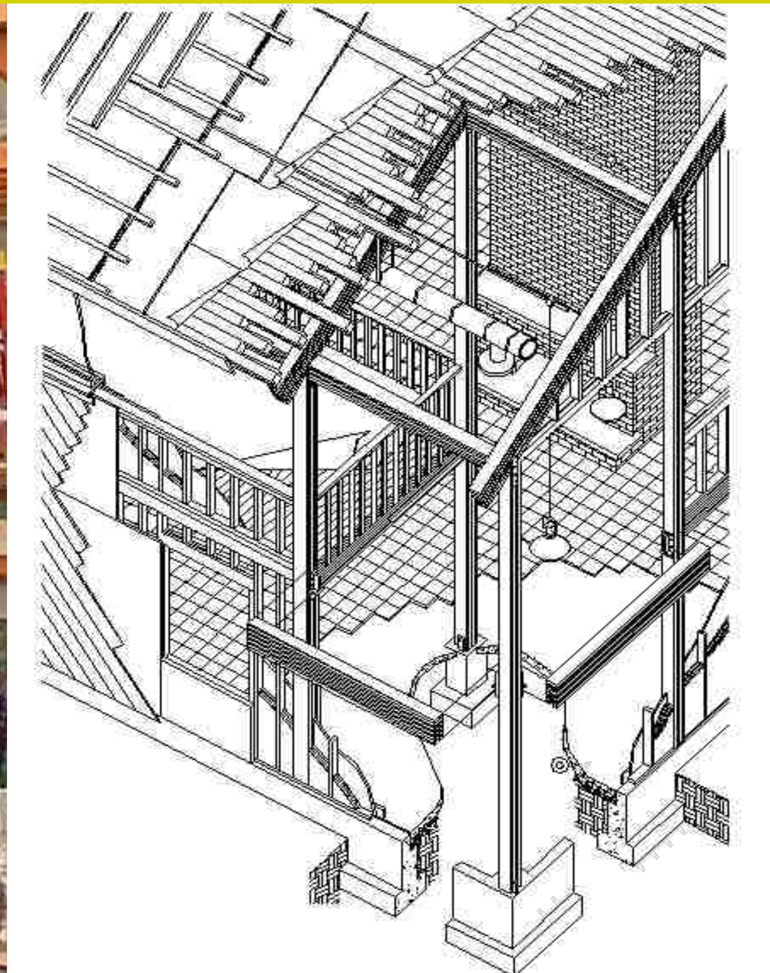


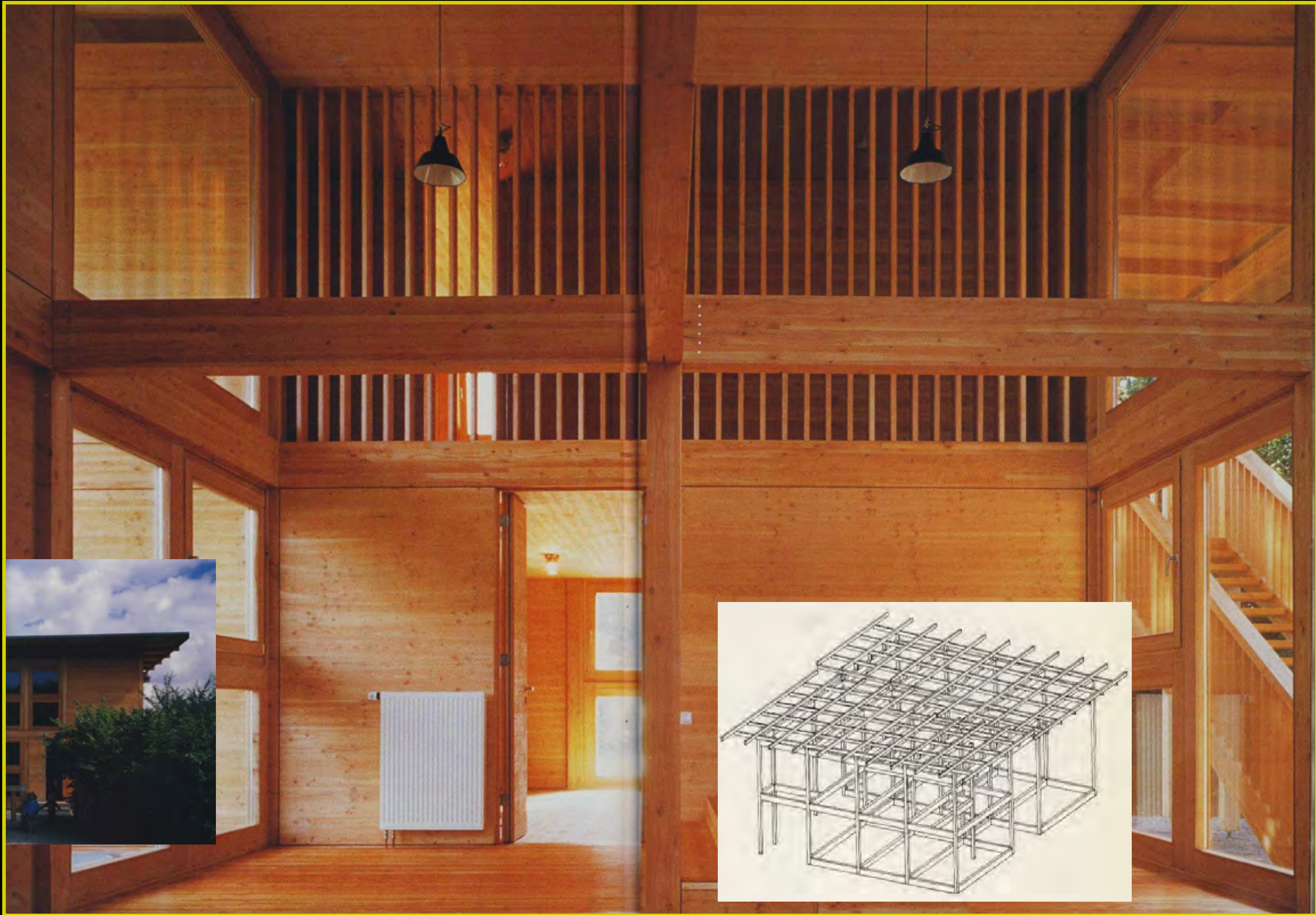
Bone/Levine Architects: 'Milanville House', Milanville, Pennsylvania 2002

POST + BEAM CONSTRUCTION:

STRUCTURE ↔ SKIN



HEAVY TIMBER CONSTRUCTION: GLULAM; LONG-SPAN

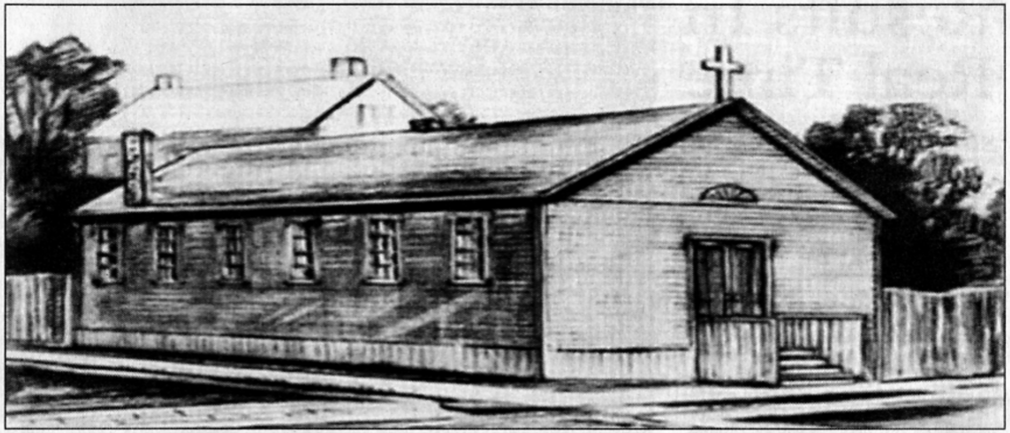


INVENTION OF LIGHT FRAMING AUGUSTINE TAYLOR 1796-1891

An Idea That Didn't Blow Away

Build On Success: Taylor's balloon-frame design changed the country's housing

BY KEN SPENCER BROWN
INVESTOR'S BUSINESS DAILY



Taylor's innovative balloon-frame design for Chicago's Old St. Mary's Church, shown above in its original form, revolutionized the home building industry. The technique remains the way Americans build their houses.

Augustine Taylor just wanted to build houses.

So he did — and in the process, he became a revolutionary. If home-ownership is a cornerstone of the American Dream, then Taylor (1796-1891) is one of its key architects.

The Chicago builder invented the construction technique known as balloon framing. The idea — and Taylor's resolve to promote it amid resistance and mockery — transformed American life.

Thanks to his invention, quality housing went from being a privilege of the wealthy to the birthright of just about anyone. It made home building faster, too, and fueled the country's westward expansion.

Most homes built today use some variation of balloon-frame construction, says Ralph Gillis, a partner at New York City architecture firm Gillis Previti and one of the top residential architects in the country.

"Everyone has the aspiration to live in (his or her) own home," he said in an interview. "A home transforms your life. (Before Taylor) you couldn't build houses on a widespread basis."

Taylor's technique is far more famous than the man himself. He was born near Hartford, Conn., the son of a carpenter. He learned his father's trade by working with him, listening carefully when the older Taylor explained his methods.

His father's death forced 17-year-old Taylor to use his skills to support the family. He later supported

were easier to build, but whole logs were getting harder to find on the Great Plains.

Taylor knew the problem first-hand. His spent his first two weeks in Chicago sleeping in a loft.

Rather than just living with the inconvenience, Taylor paid close attention to several innovations he thought could lead to a solution.

Thanks to a machine invented by Jacob Perkins, iron nails had gotten cheaper. A nascent railroad and other transportation advances made it easier to ship wood.

Touch Of Genius

"The solution to the housing problem was within reach," Armstrong wrote. "(It) simply required the

them with lighter 2x4s and 2x6s set close together. He also used studs and cross members to brace the structure.

Not everyone was impressed. Taylor's fellow carpenters dismissed the idea.

According to some accounts, the term "balloon frame" was meant as a mocking nickname because the frames looked as insubstantial as a balloon. Taylor's fellow carpenters predicted the structures would blow away at the first strong wind.

Undeterred, Taylor pressed on with his idea.

The structures stayed put. As Armstrong points out, so did the name — and, more important, the technique. A housing boom erupted in Chica-

Taylor's technique endures.

As Lienhard put it, "It became, and remains, the way by which America houses itself."

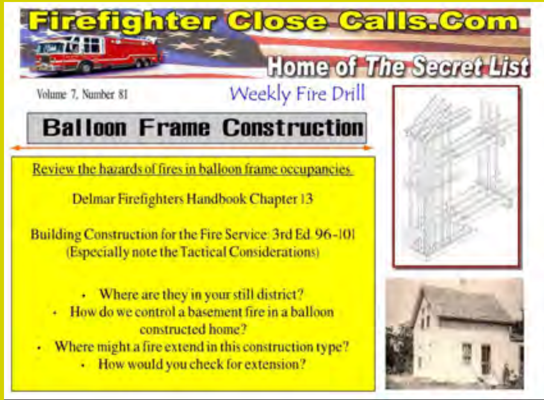
Builders over the years have improved Taylor's techniques. Today, most use a variation called platform framing that's less vulnerable to fire.

Spearheading Change

Standard-sized materials also gave rise to new housing-related industries. With easy construction but few architects, blueprints in magazines and books became a popular read. Sears, Roebuck & Co. would eventually offer pre-made housing kits buyers could assemble on site.

Standard sizes also made it possi-

BALLOON FRAME ...TECTONICS...


Firefighter Close Calls.Com
Home of The Secret List

Volume 7, Number 81

Weekly Fire Drill

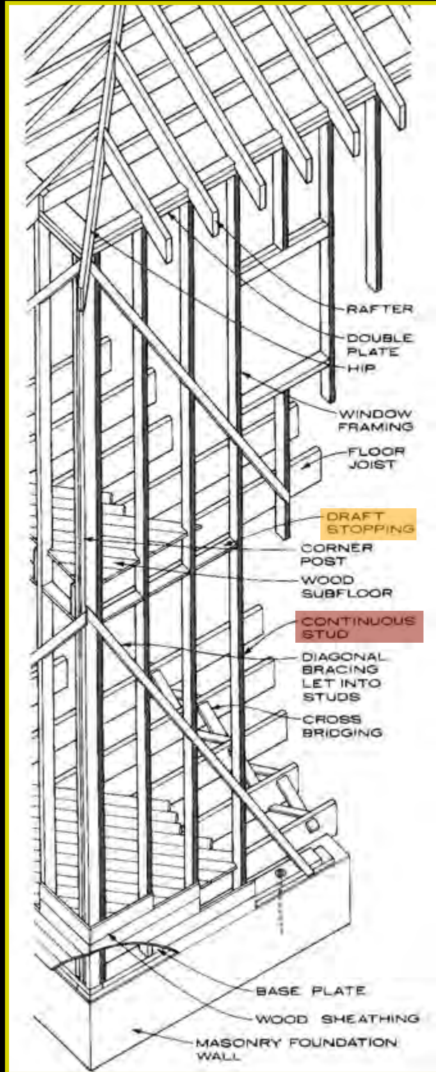
Balloon Frame Construction

Review the hazards of fires in balloon frame occupancies

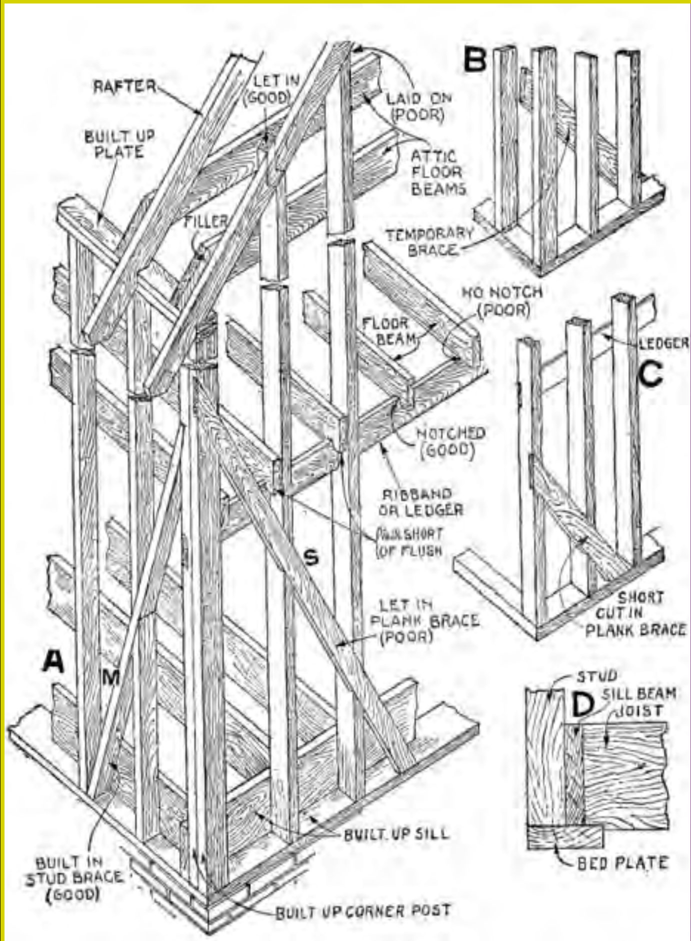
Delmar Firefighters Handbook Chapter 13

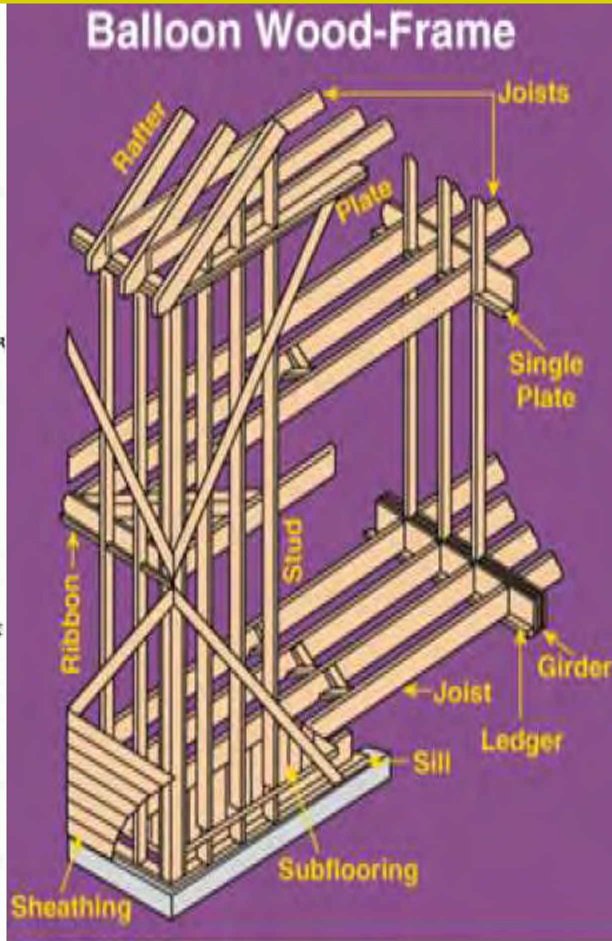
Building Construction for the Fire Service: 3rd Ed. 96-101
(Especially note the Tactical Considerations)

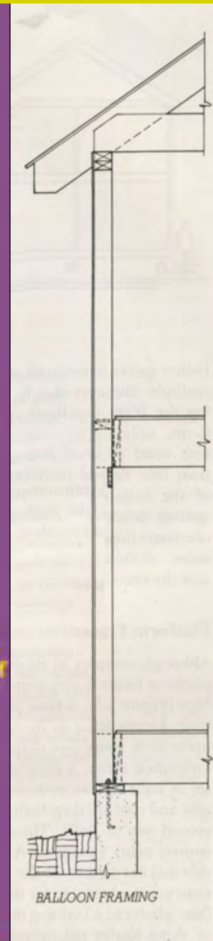
- Where are they in your still district?
- How do we control a basement fire in a balloon constructed home?
- Where might a fire extend in this construction type?
- How would you check for extension?



BALLOON FRAME

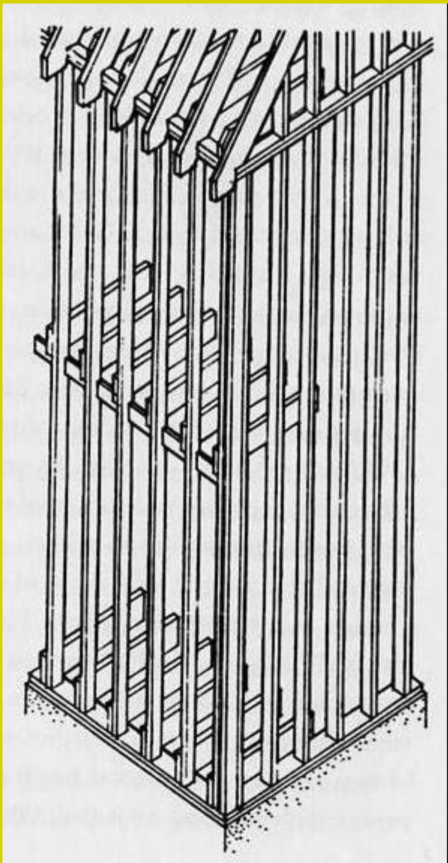


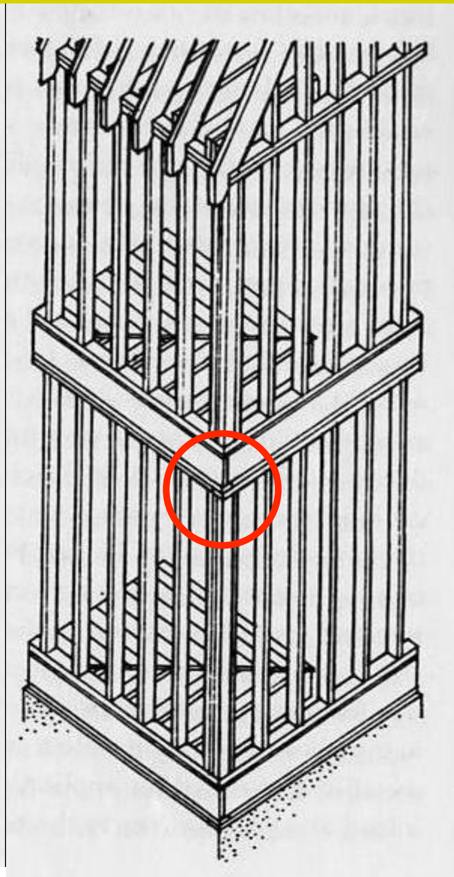




PLATFORM FRAME

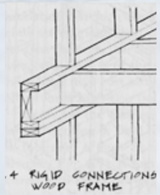
...TECTONICS...

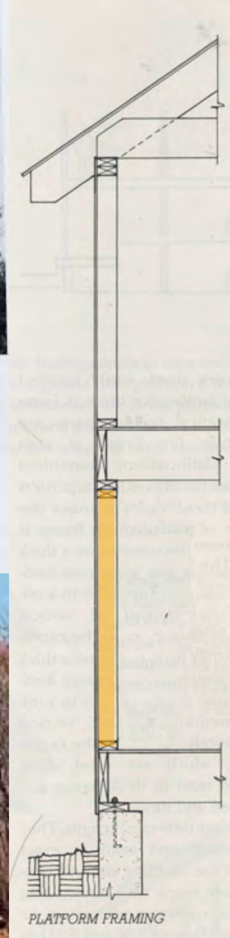




BALLOON FRAME ↔ PLATFORM FRAME

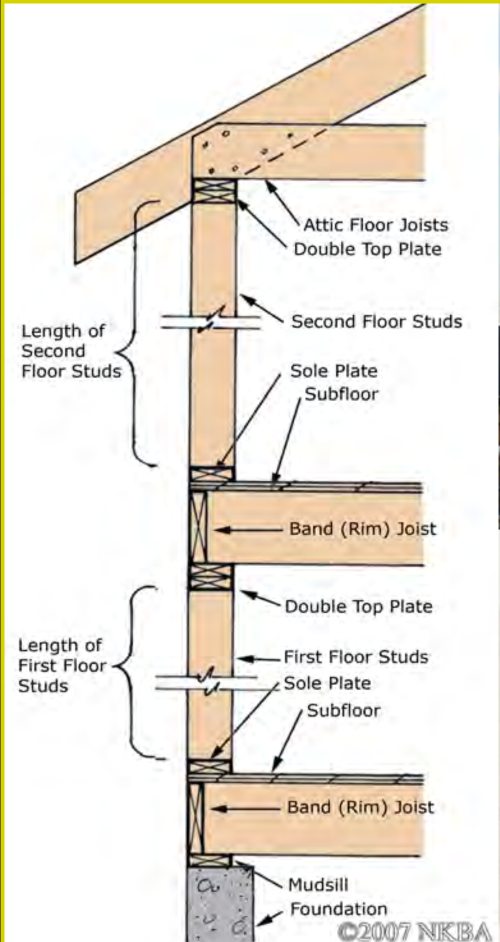
Wind-tilted farmhouse in upstate New York showing undeformed triangle of the gable, below which all the rectangular forms have been racked into parallelograms because of the complete absence of diagonal members. (Photograph by Lee Brown Coye.)

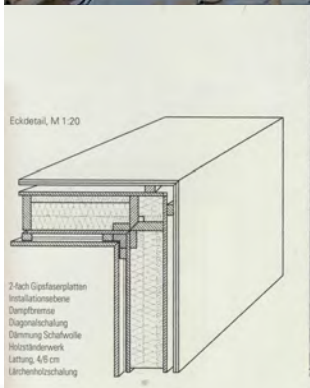




PLATFORM FRAME

…TECTONICS…





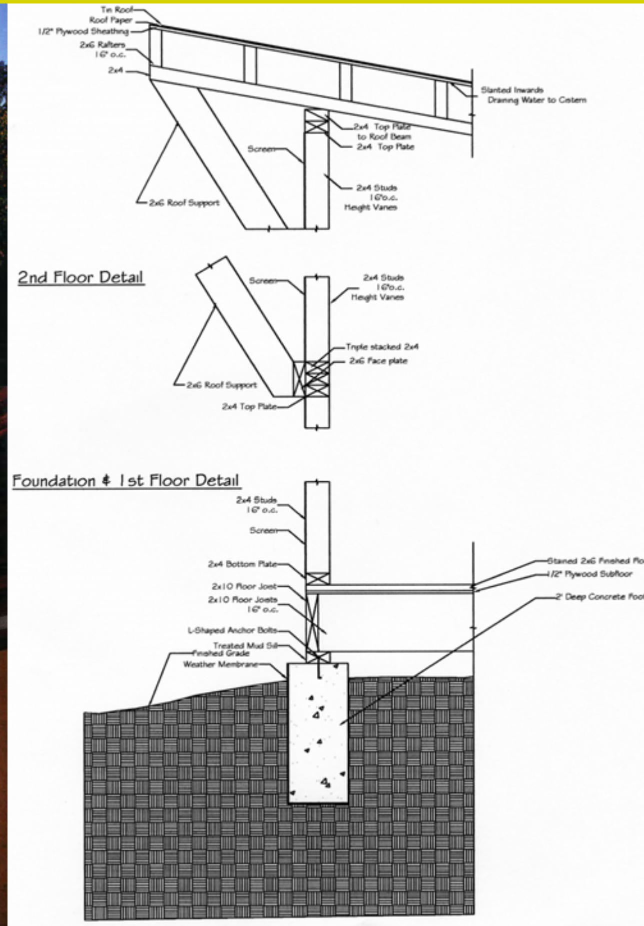
Schnitt durch eine Wand mit Schafwolldämmung

PLATFORM FRAME

”SHEATHING”

PLATFORM FRAME

"BUTTERFLY HOUSE"



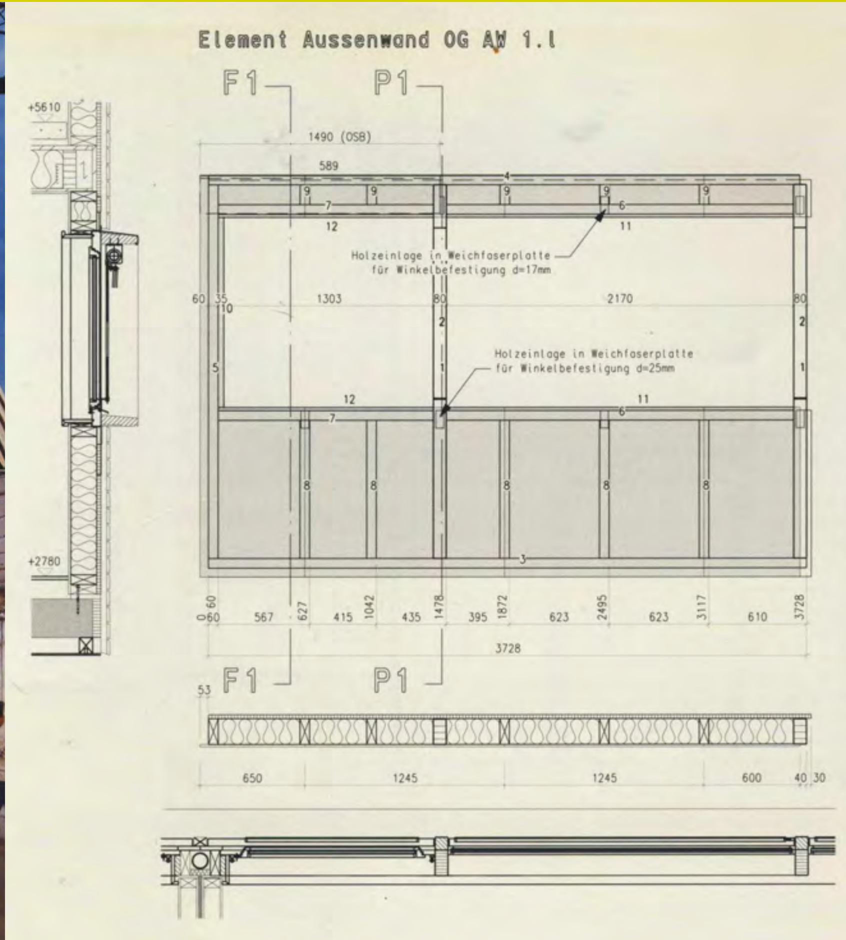
S.Mockbee + Rural Studio: 'Harris House', Mason's Bend, Alabama 1997

FRAMING - SHEATHING ?

Dorte Mandrup Arch.: ‘Community Center’, Copenhagen, Denmark 2001

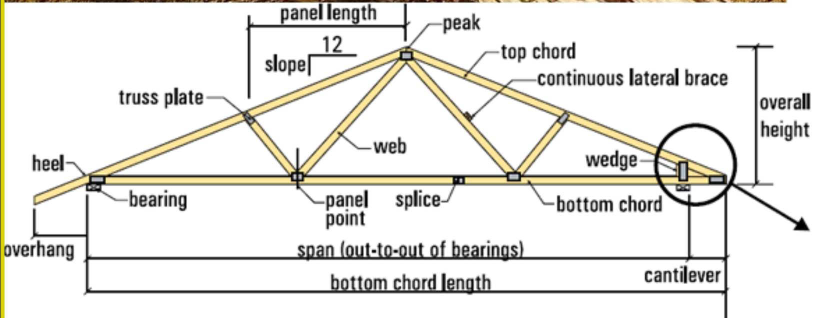
PREFABRICATION

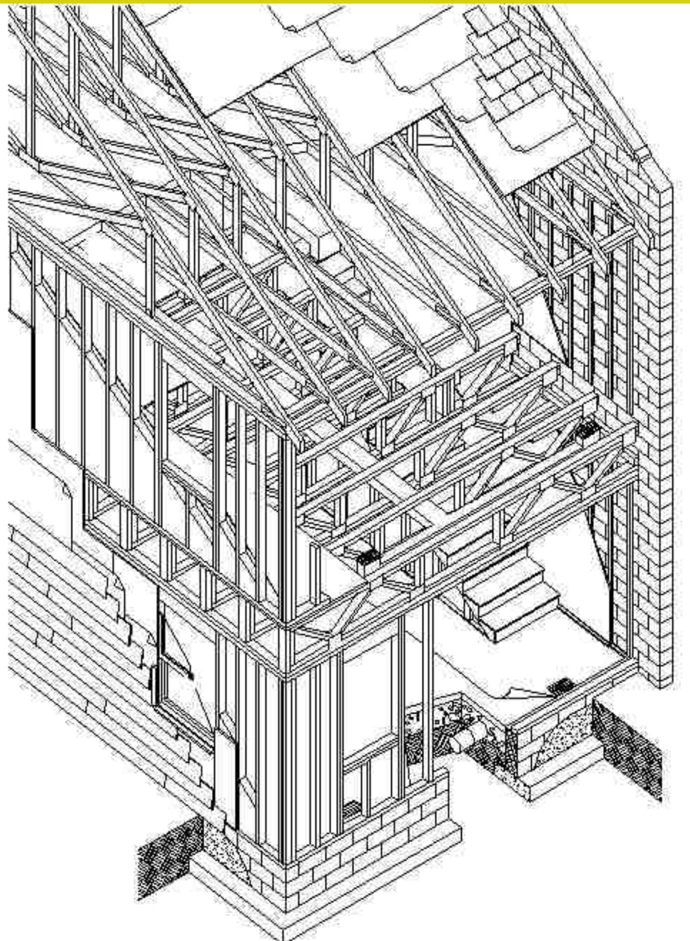
LIGHT FRAMING; FRAMED PANELS



PREFABRICATION

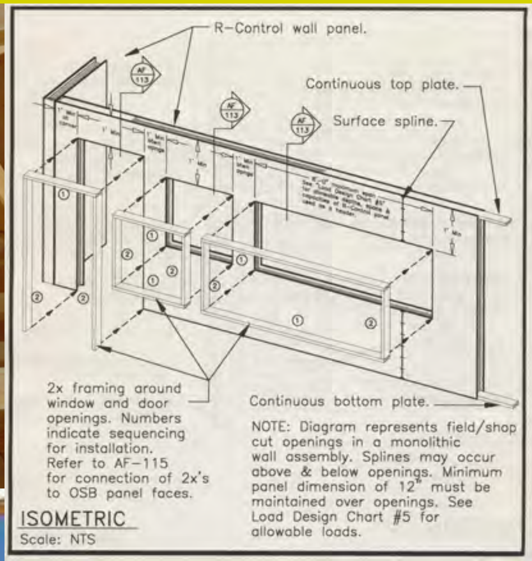
LIGHT FRAMING; TRUSSES





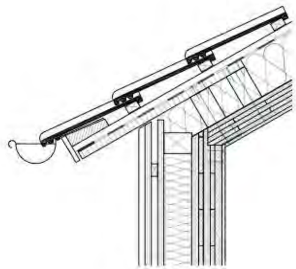
PREFABRICATION

STRUCTURAL INSULATED PANEL (SIP)

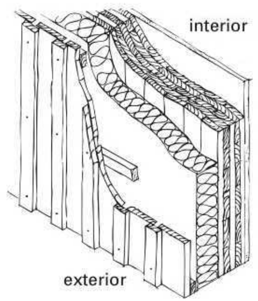


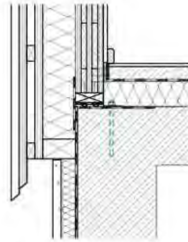
PREFABRICATION

SOLID PANEL CONSTRUCTION (CLT)



Detail eaves

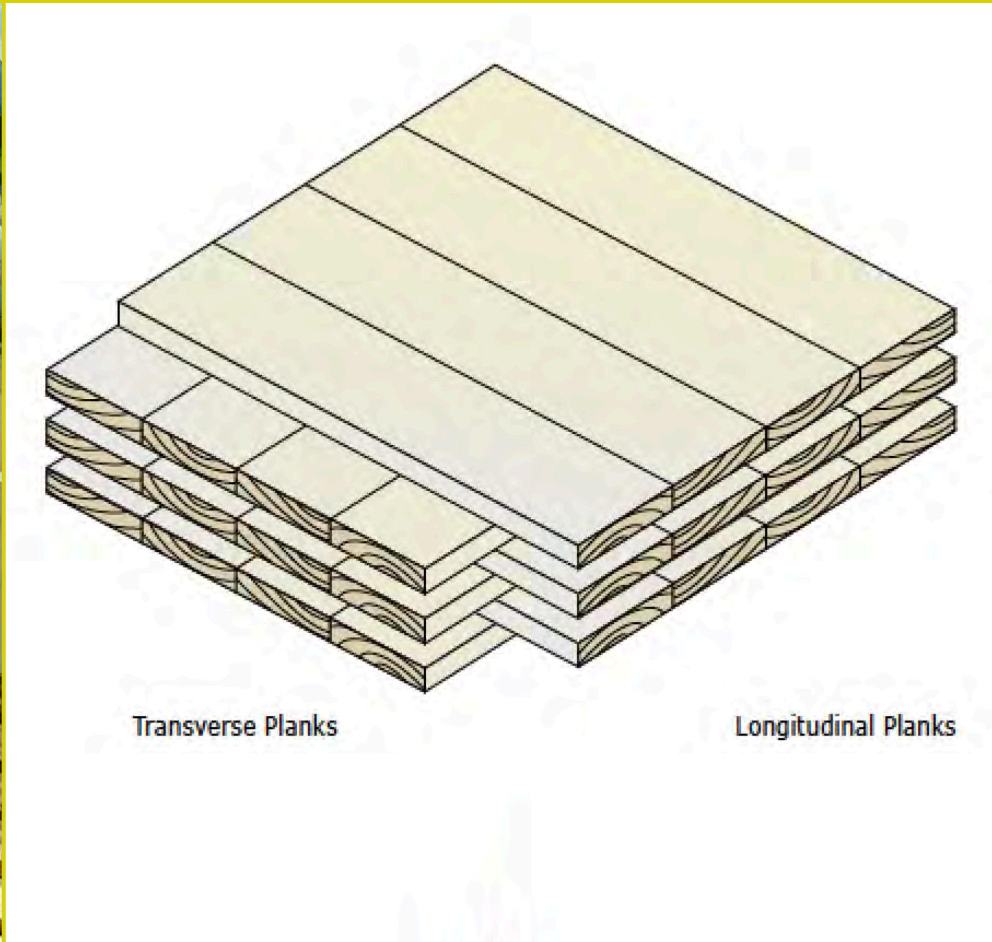




Plinth detail with threshold

PREFABRICATION

CROSS LAMINATED TIMBER (CLT)



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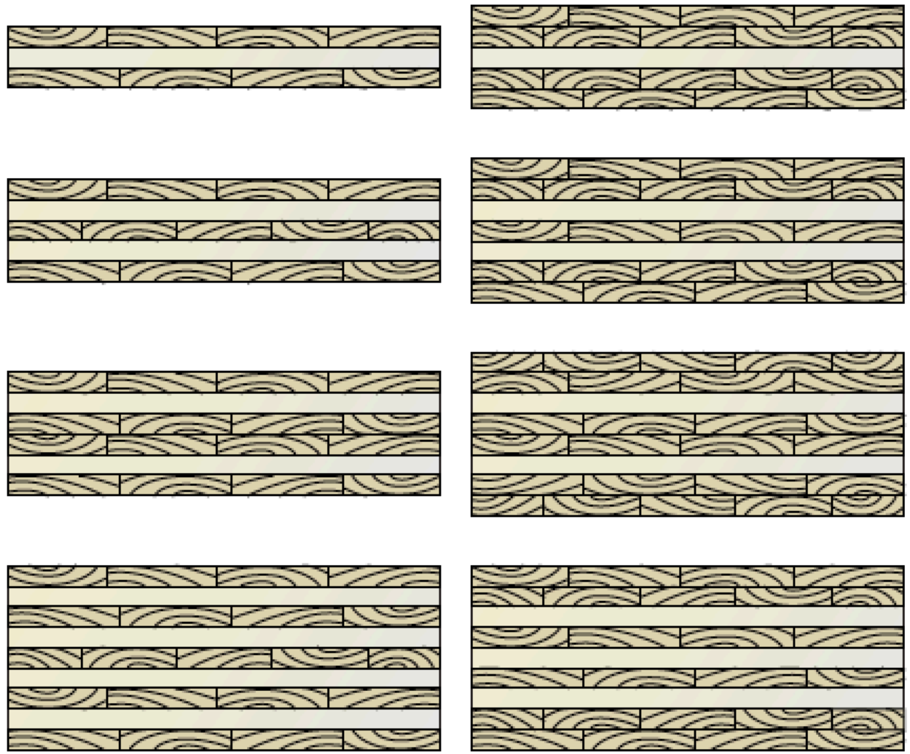
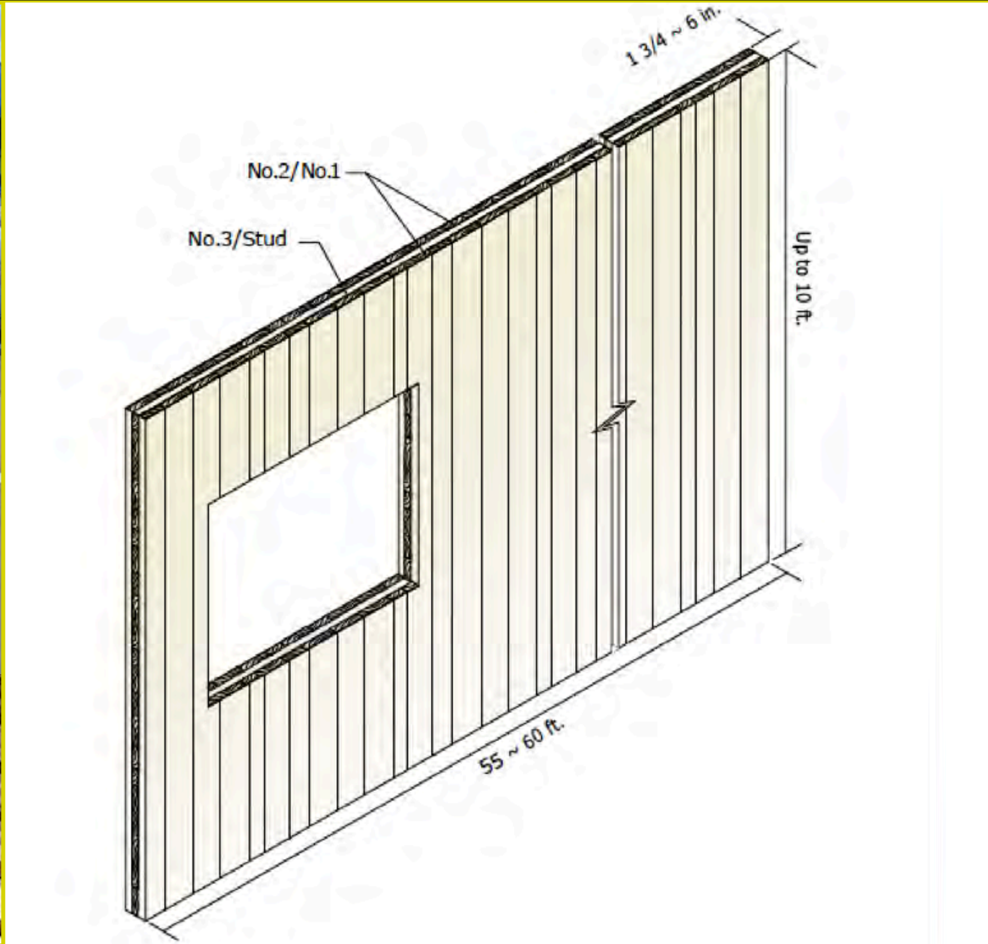


THICKNESS: 1-3/4" – 6"

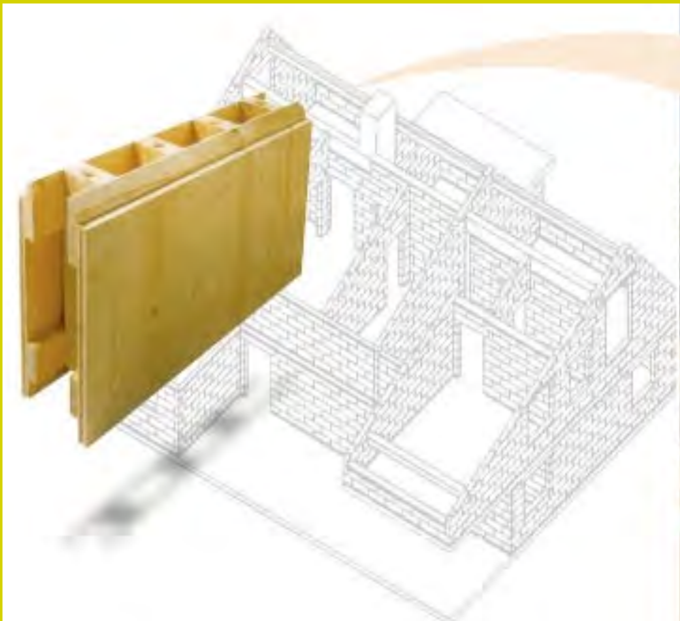
PREFABRICATION

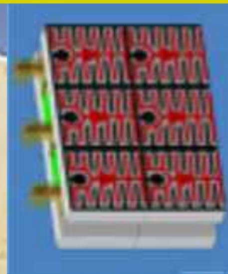
CROSS LAMINATED TIMBER (CLT)

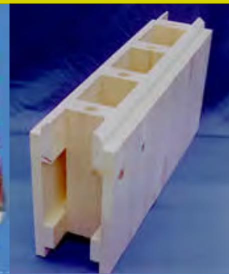


PREFABRICATION

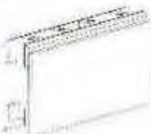
MODULAR ELEMENT CONSTRUCTION



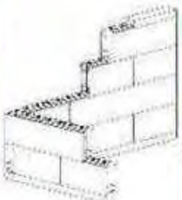




The **STEKO** Module



The **STEKO** Wall



The **STEKO** House

CONNECTORS

MOST COMMON:
(IN ORDER OF DECREASING STRENGTH)

- TIMBER CONNECTORS (SPLIT RING, SHEAR PLATES)
- BOLTS
- LAG SCREWS
- WOOD SCREWS
- NAILS

CONNECTORS

NAILS

Fig. 6-29 Sizes of common nails.

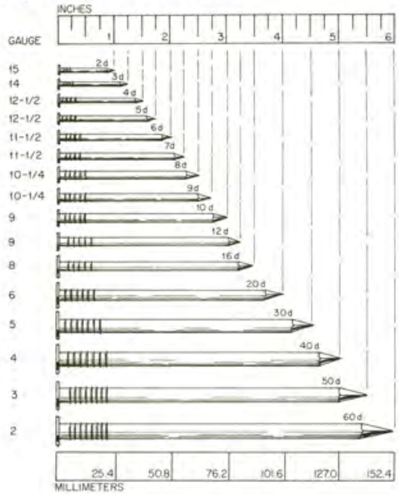
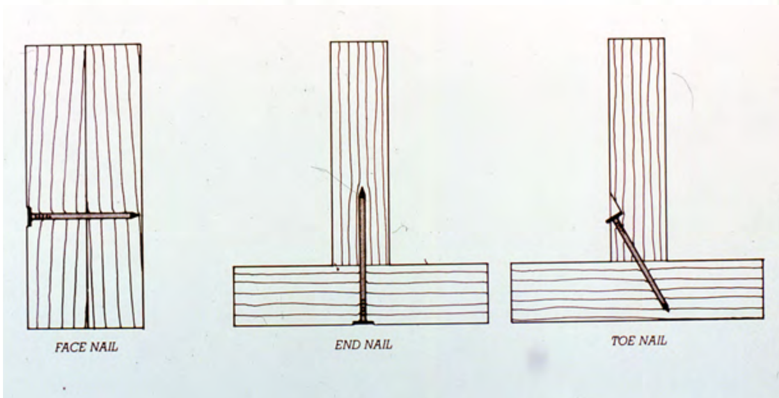
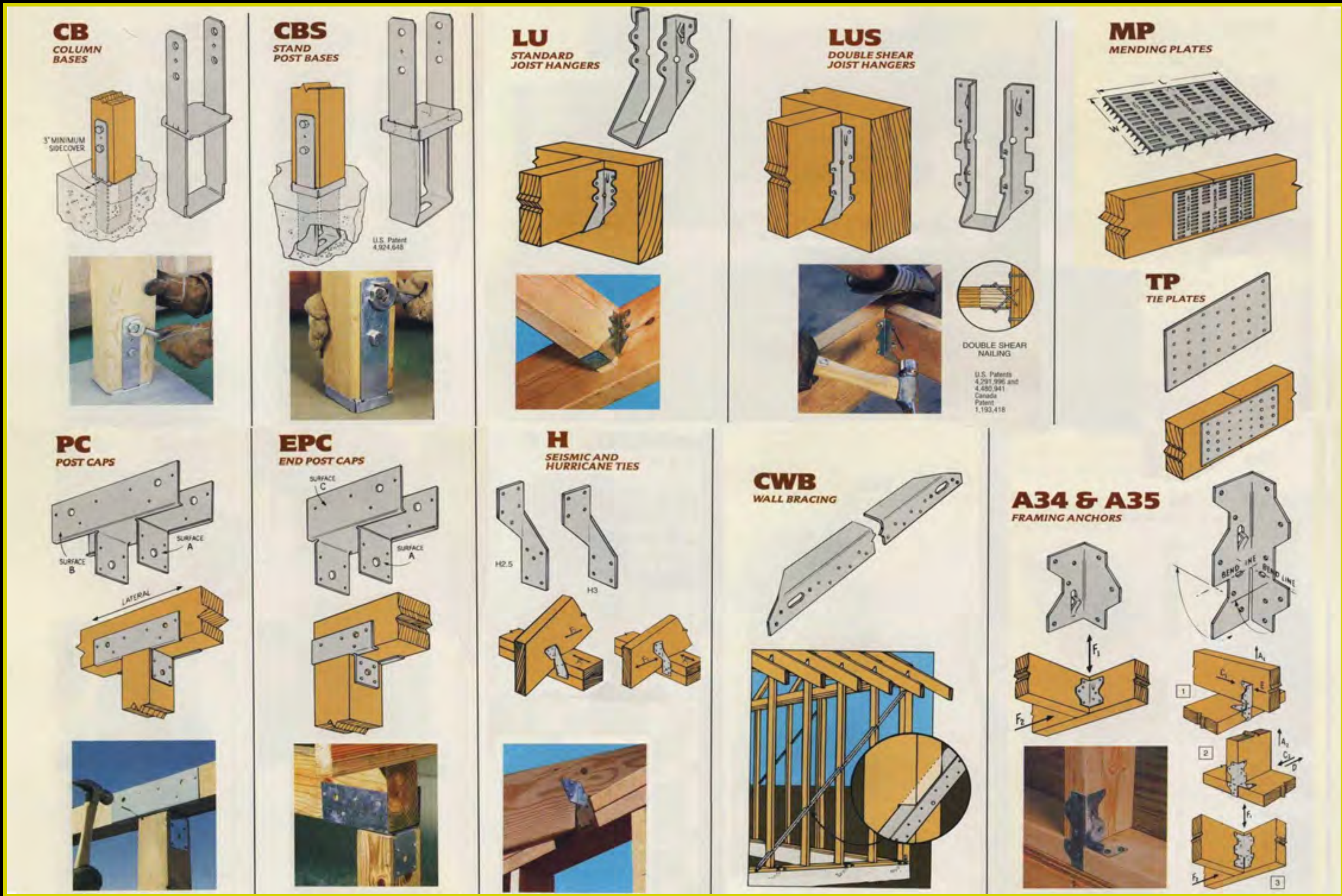


Fig. 6-30 Nail types.



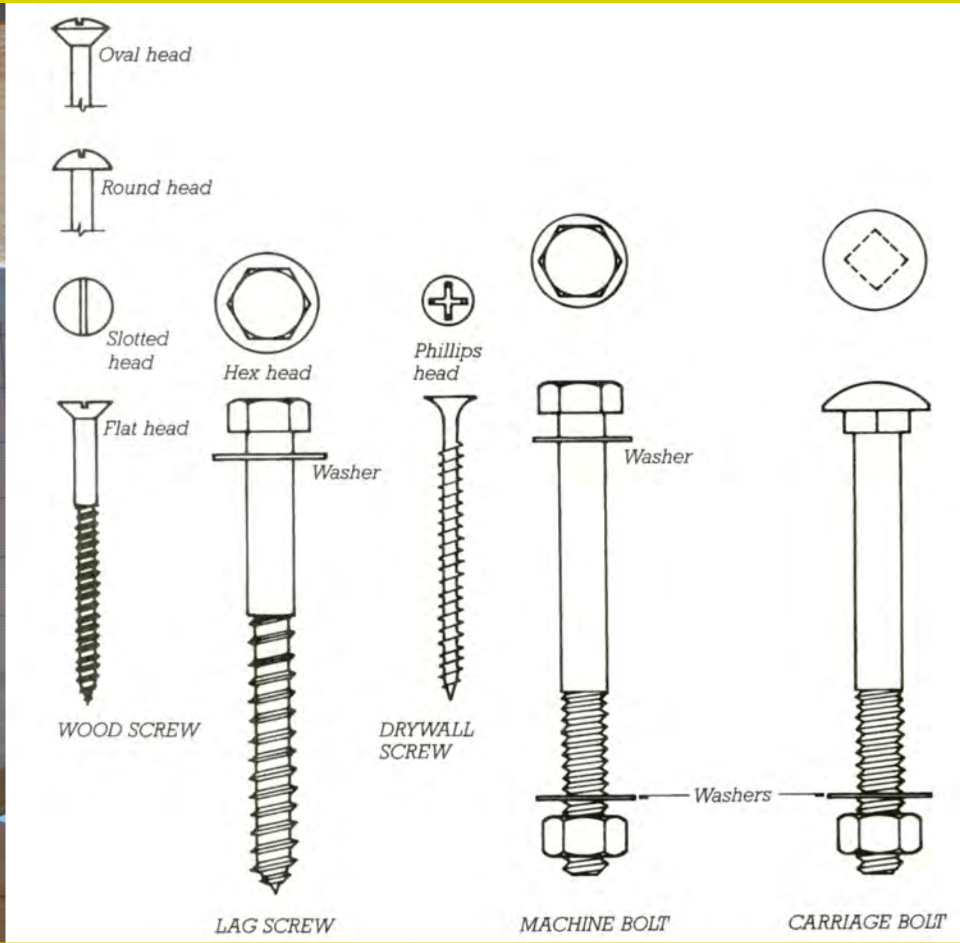
CONNECTORS

SHEET METAL FRAMING FASTENERS



CONNECTORS

BOLTS, SCREWS



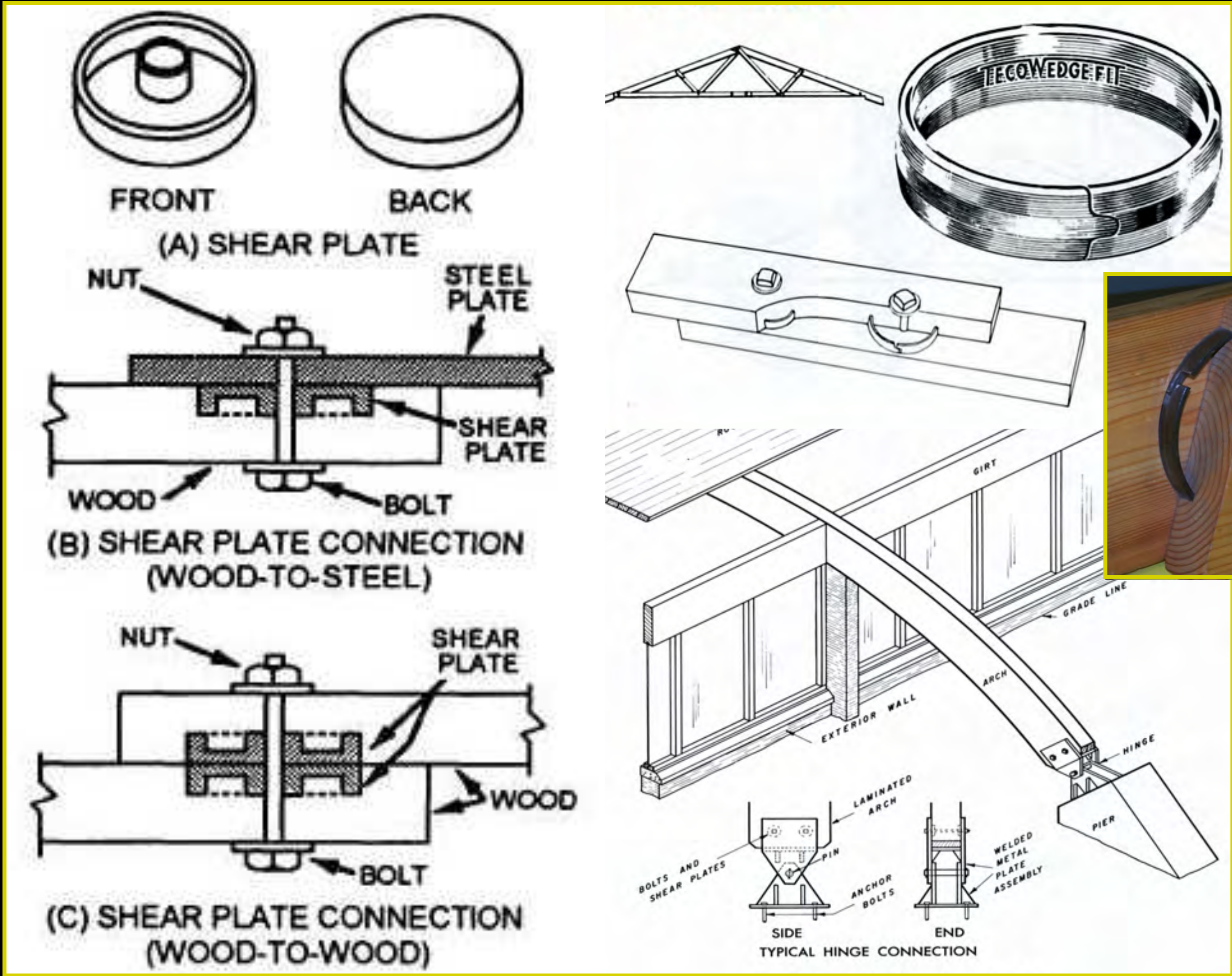
CONNECTORS

’ TIMBER CONNECTORS’

SHEAR
PLATE

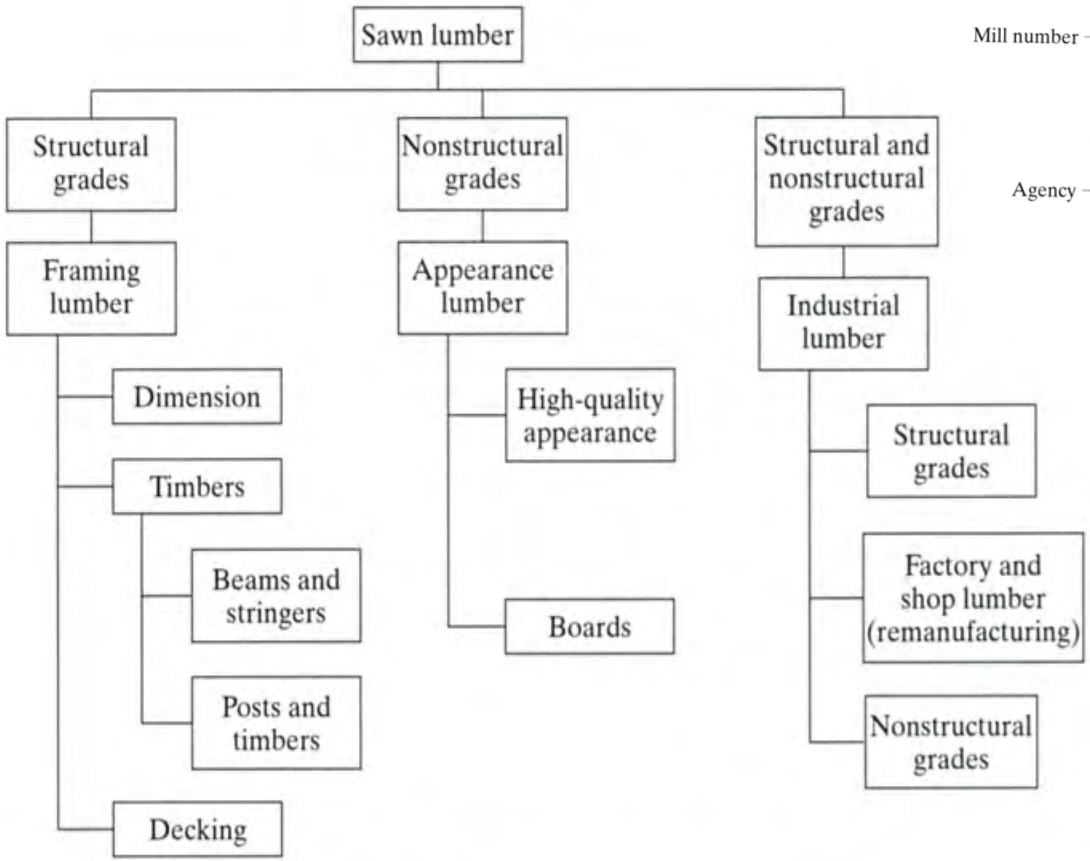
SPLIT
RING

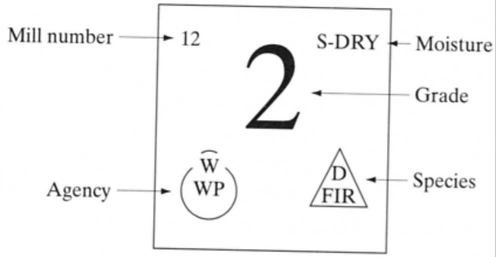
ARCH
HINGE



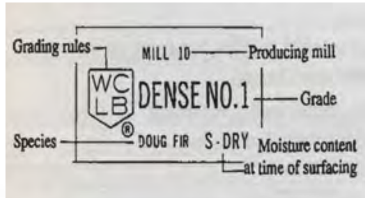
“GRADING”:

”GRADE STAMP”





(a)



NOMINAL SIZES + ACTUAL SIZES: "DRESSING/SURFACING"

TABLE 5.4 NOMINAL AND DRESSED SIZES OF SAWN LUMBER

	Thickness (in.)			Width (in.)		
		Minimum dressed			Minimum dressed	
Use category	Nominal	Dry	Green	Nominal	Dry	Green
Boards	$1–1\frac{1}{2}$	3/4	25/32	2	$1\frac{1}{2}$	$1\frac{9}{16}$
		$1\frac{1}{4}$	$1\frac{9}{32}$	3	$2\frac{1}{2}$	$2\frac{9}{16}$
				4	$3\frac{1}{2}$	$3\frac{9}{16}$
				5	$4\frac{1}{2}$	$4\frac{5}{8}$
				6	$5\frac{1}{2}$	$5\frac{5}{8}$
				7	$6\frac{1}{2}$	$6\frac{5}{8}$
				8	$7\frac{1}{4}$	$7\frac{1}{2}$
				9	$8\frac{1}{4}$	$8\frac{1}{2}$
				10–16	3/4 less than nominal	1/2 less than nominal
Dimension	2–4	1/2 less than nominal	7/16 less than nominal	2–4	1/2 less than nominal	7/16 less than nominal
				5, 6	1/2 less than nominal	3/8 less than nominal
				8–16	3/4 less than nominal	1/2 less than nominal
Timbers	5 and larger	—	1/2 less than nominal	5 and greater	—	1/2 less than nominal
Decking[a]	2–4	1/2 less than nominal	—	4–6	1 less than nominal	—
				8–12	$1\frac{1}{4}$ less than nominal