Engineered wood products

Sheikh Ali Ahmed
Senior Lecturer
Department of Forestry and Wood Technology
Faculty of Technology
LNU, Växjö

Wood

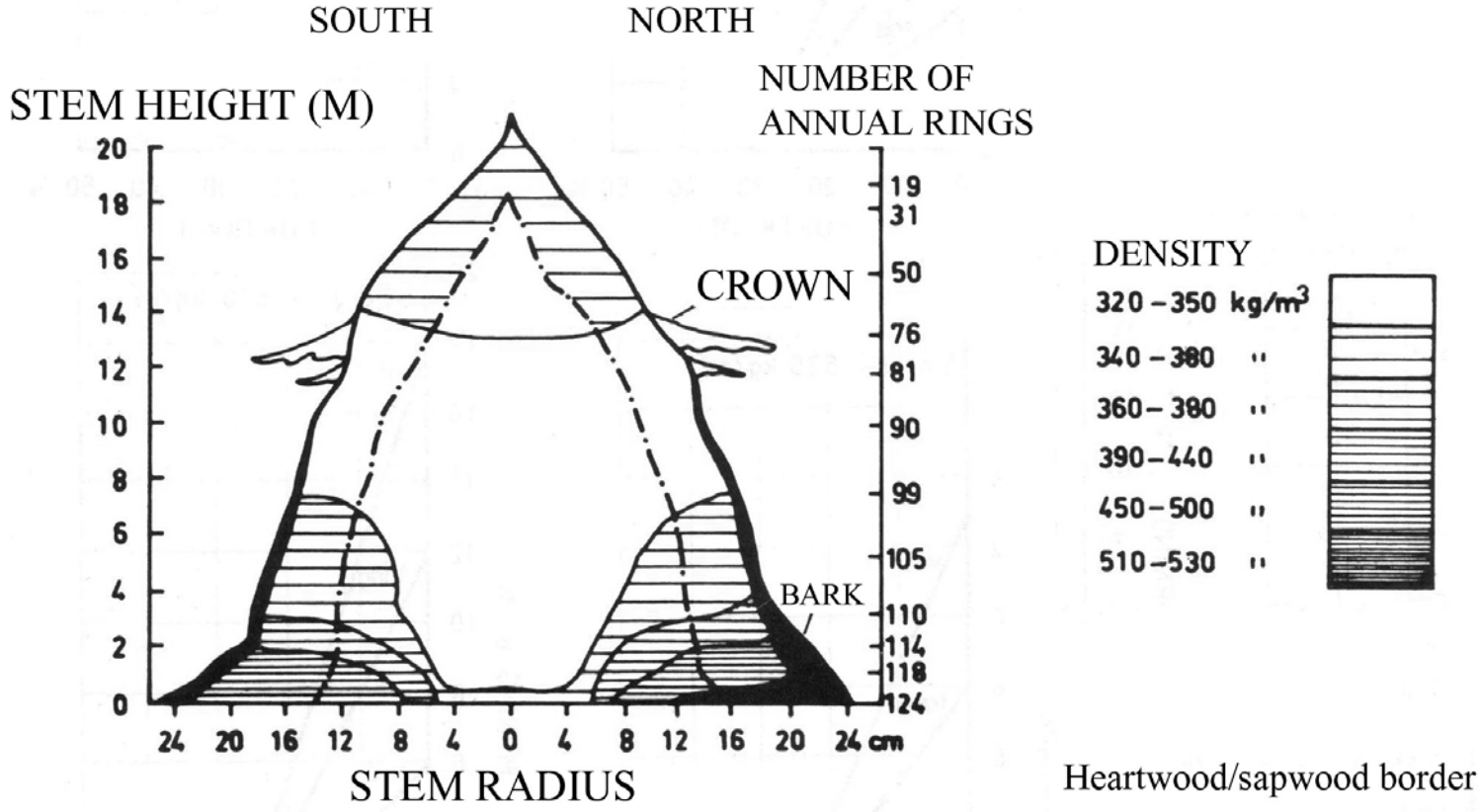
Softwood tree

Softwood
Juvenile wood
Species
Heartwood Sapwood **Hardwood**
Latewood **Direction**
Earlywood Matured wood

Hardwood tree

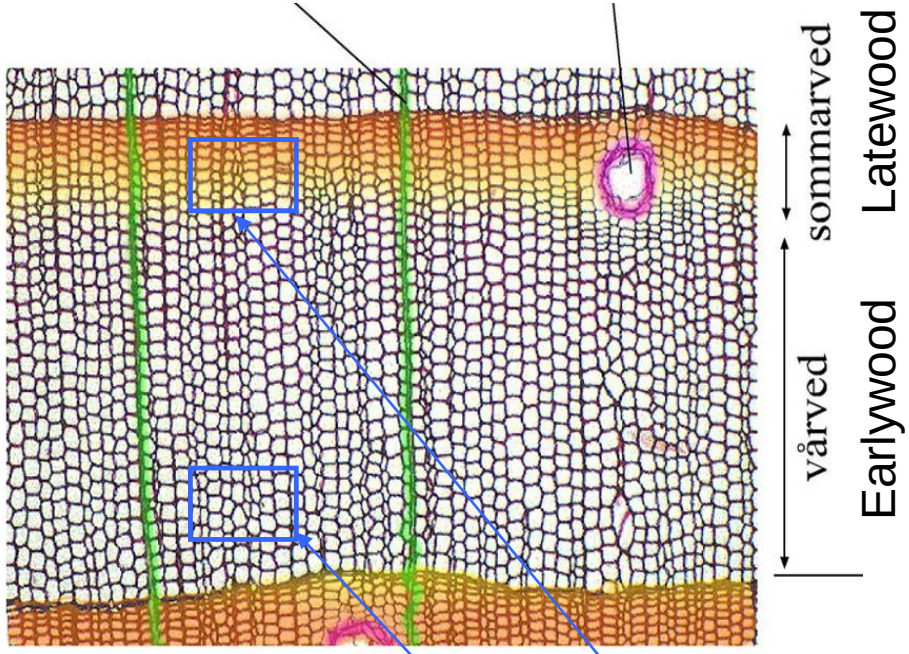
Variation in density

Variation in a tree



Example on density and heartwood formation in different parts of a pine tree (with average density 366 kg/cubic meter). The distance between bark and heartwood/sapwood border is, from root to top, almost constant.
(*Data R Trendelburg, figure from Torkhandboken, Esping*)

MSP

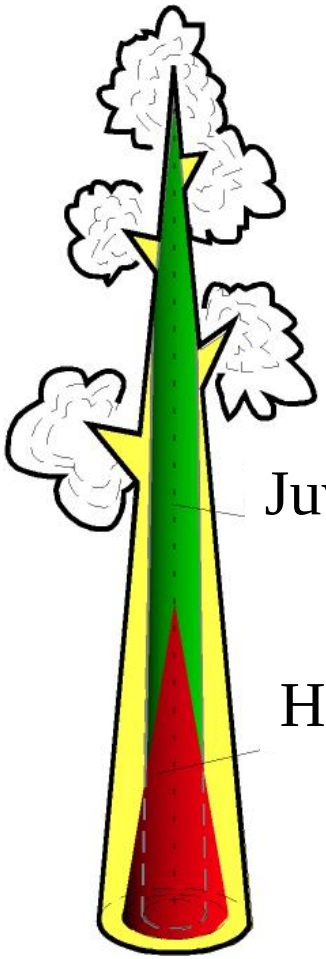


Variation within the annual ring

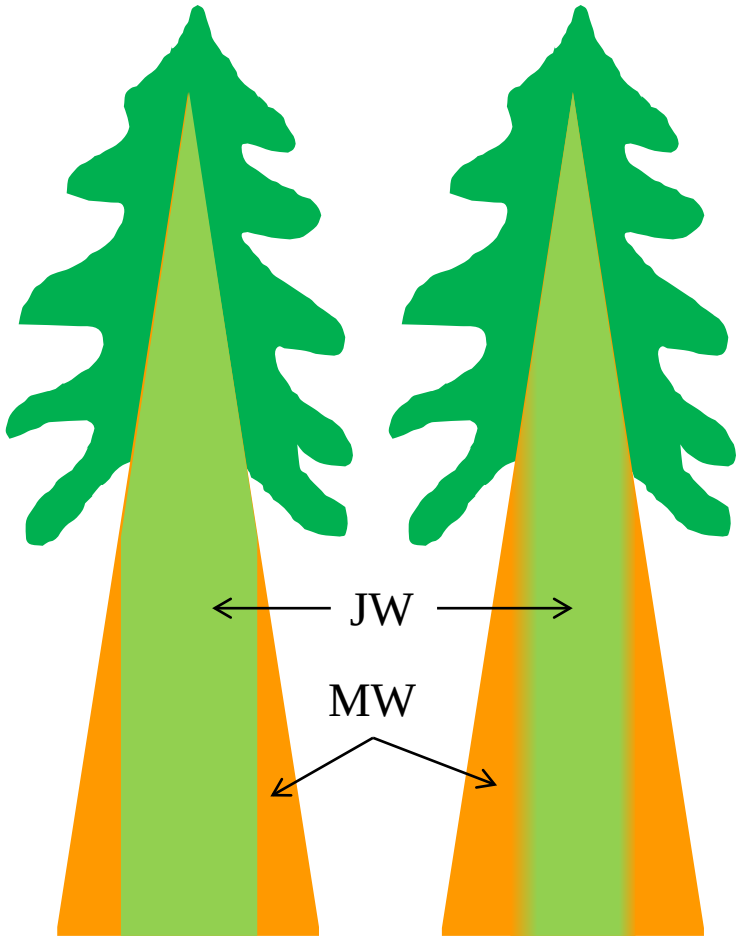
Pine and Spruce:

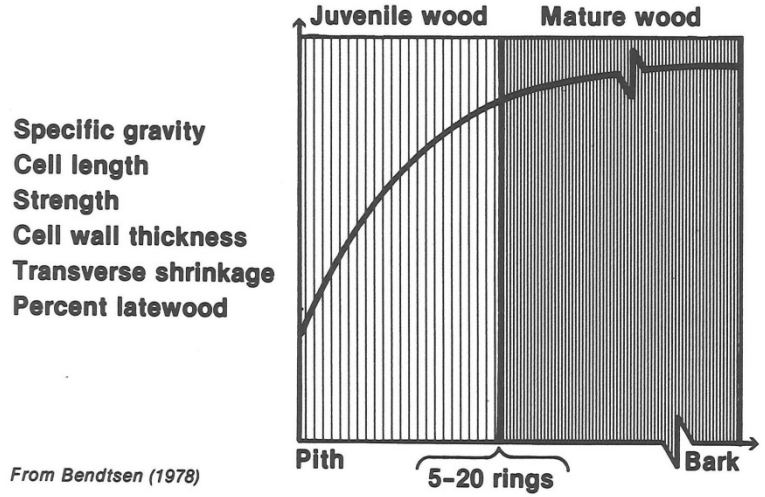
Latewood density ca 900 kg/m^3

Earlywood density ca 300 kg/m^3

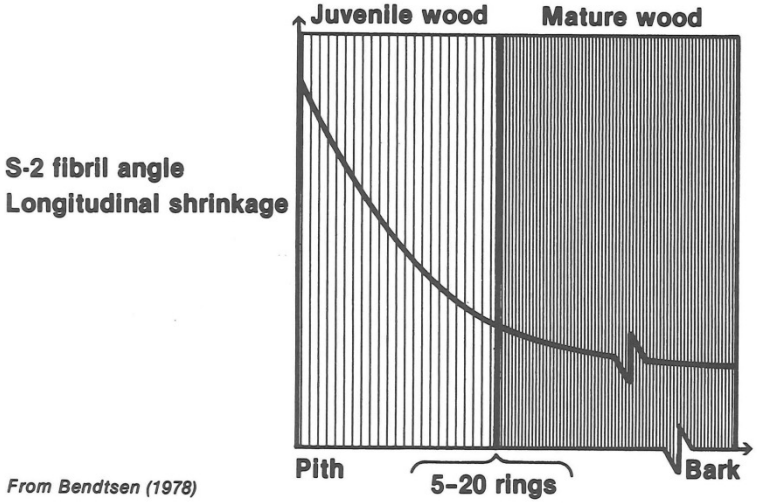


- 10-15 first developed annual rings
- Bigger fibril angle in S_2
- Bigger longitudinal shrinkage
- Lower density
- Shorter cell length- thinner walls





From Bendtsen (1978)



From Bendtsen (1978)

Bowyer JL, Shmulsky R, Haygreen JG (2007) Forest Products & Wood Science: An Introduction. 5th Edition. Blackwell Publishing Ltd., Oxford, United Kingdom

http://wood280.sites.olt.ubc.ca/files/2012/08/WOOD-280-15W-7-Juvenile-wood.ppt.

Shrinkage and swelling

Below FSP => shrinkage

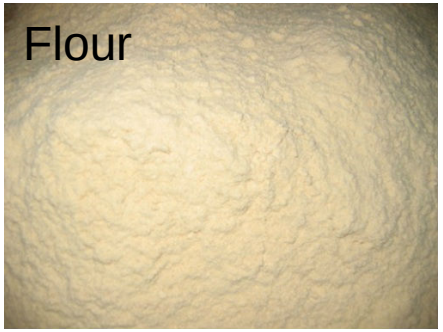
Shrinkage from FSP to MC=0 almost linear.

Moistening from MC=0 to FSP swelling also almost linear.

The movements due to change in MC are very different in the different 3 main directions => anisotropic.

How many solid products around you???

Conversion



Cellulose

Definition

Engineered wood is also called-

- composite wood
- man-made wood or
- manufactured board

It includes a range of derivative wood products which are manufactured by binding or fixing-

- the strands
- particles
- fibers
- veneers or
- boards of wood together with adhesives, or other methods of fixation to form composite materials

In short-

An Engineered Wood Product (EWP) is a product that has gone through a process to provide better or more predictable properties.

- Longer spans
- Greater load carrying capacity
- More design flexibility

Examples

Plywood

Oriented Strandboard (OSB)

Glulam

Parallel Strand Lumber (PSL)

Laminated Veneer Lumber (LVL)

Laminated Strand Lumber (LSL)

I-Joists / Open-Web Joists

Trusses

Examples

Solid wood products

Engineered wood products

Types of engineered wood products

Strands based

- Oriented strand board
- Parallel strand lumber
- Laminated strand lumber
- Oriented strand lumber

Particle based

- Particle board

Veneer based

- Plywood
- Laminated veneer lumber
- Overlaid products

Lumber based

- Glued laminated timbers
- Cross laminated timber
- Finger-joined lumber
- Edge glued products

Combinations

- I-Joists
- Structurally insulated panels

Fiber based

- Fiber reinforcement
- Wood plastic composites
- Medium density fiber board
- Hardboard or high density fiber board

Advantages of EWPs

- Can be designed to meet application-specific performance requirements
- Versatile and available in a wide variety of thicknesses, sizes, grades etc.
- EWPs are designed and manufactured to maximize the natural strength and stiffness characteristics of wood
- Glued laminated timber (glulam) has greater strength and stiffness than comparable dimensional lumber
- Offer more design options without sacrificing structural requirements
- Engineered wood panels are easy to work with
- Make more efficient use of wood
- Sustainable design is possible using relatively small trees

Distadvantages of EWPs

- Some products may burn more quickly than solid lumber
- They require more primary energy for their manufacture than solid lumber
- The adhesives used in some products may be toxic
- Some engineered wood products, such as those specified for interior use, may be weaker and more prone to humidity-induced warping than equivalent solid woods. Most particle and fiber-based boards are not appropriate for outdoor use because they readily soak up water
- Combustible
- Biodegradable

Dimensional stability of timber and boards. Change in dimensions from 30% to 90% relative humidity (Dinwoodie 1981)

	Direction of grain or board length		
	Parallel (%)	Perpendicular (%)	Thickness (%)
Douglas fir Beech	Negligible Negligible	2.0-2.4 2.6-5.2	2.0-2.4 2.6-5.2
Plywood Douglas fir	0.24	0.24	2.0
Particle board UF bonded PF bonded MF/UF bonded	 0.33 0.25 0.21	 0.33 0.25 0.21	 4.7 3.9 3.3
MDF	0.24	0.25	4-8

Strength properties of timber and boards (Dinwoodie 1981)

	Thickness (mm)	Density (kg m^{-3})	Bending strength (MPa)		Bending stiffness (MPa)	
			∥	⊥	∥	⊥
Solid timber Douglas fir	20	500	80	2.2	12700	800
Plywood Douglas fir Douglas fir	4.8 19	520 600	73 60	16 33	12090 10750	890 3310
Chipboard UF bonded PF bonded MF/UF bonded	18.6 19.2 18.1	720 680 680	11.5 18.0 27.1	11.5 18.0 27.1	1930 2830 3460	1930 2830 3460
MDF	9-10	680	18.7	19.2	---	---

Efficient use of wood- *Stability*

I-Joist is very efficient use of materials

Strong and consistent

Optimize strength through-

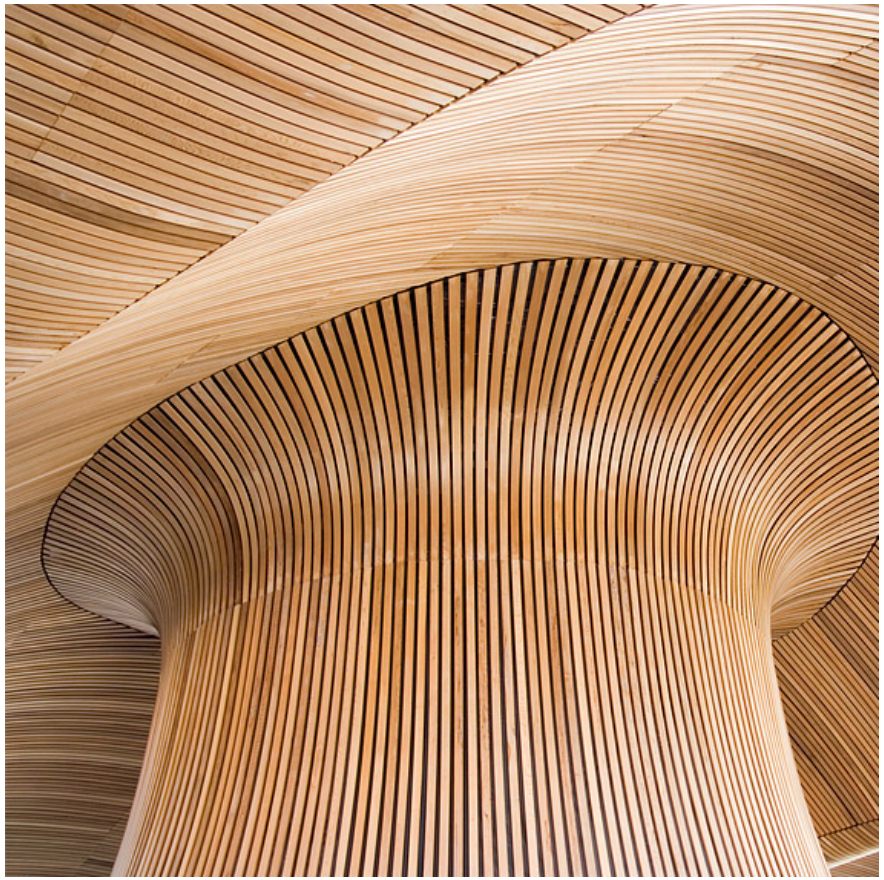
Engineered design

- Put strongest components where stresses are highest
- Configure for efficient properties

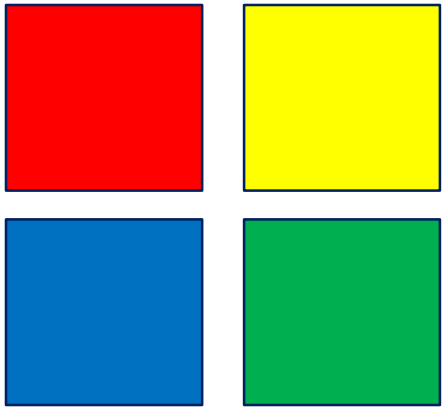
Randomization of defects to

reduce variability or increase reliability

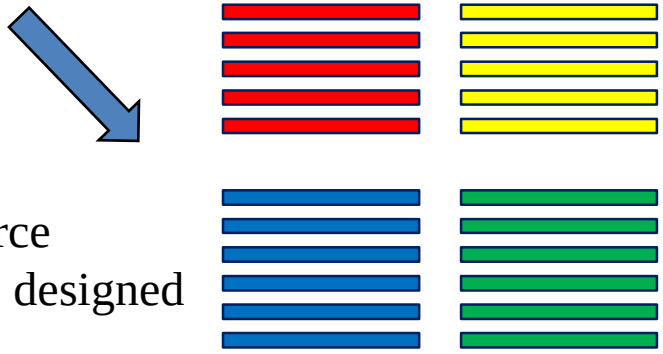
Flexible with respect to shape and size, aesthetics



Reduction of natural variability

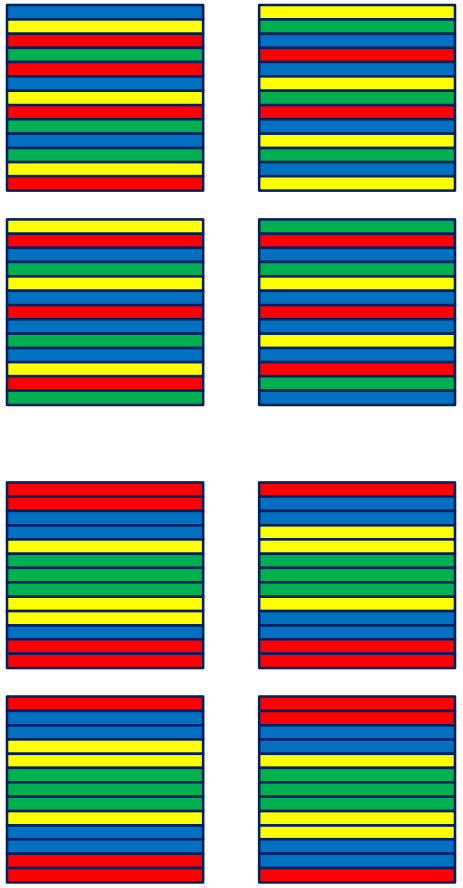


Initial source of solid wood



Wood source reduced to designed elements

Elements combined into more consistent engineered products



Strategic placement of elements

Strand based EWP

Oriented Strand Board (OSB)

OSB is formed by adding adhesives and then compressing layers of wood strands (flakes) in specific orientations.

OSB may have a rough and variegated surface with the individual strips of around 2.5 × 15 cm (1" × 6"), lying unevenly across each other and comes in a variety of types and thicknesses

www.wikipedia.org

Uses of OSB

http://apawood-europe.org/products-trademarks/i-joists/

I-joist

www.mrshed.net

Sheathing

http://lpcorp.com/products/framing/lp-solidstart-rim-board/

Rim board

Parallel Strand Lumber (PSL)

PSL is manufactured from ***veneers clipped into long strands*** laid in parallel formation and bonded together with an adhesive to form the finished structural section. The length-to-thickness ratio of the strands in PSL is around 300.

www.woodskyscrapers.com

www.stylepinner.com

Uses of PSL

- Beam and header applications where high bending strength is needed
- Load-bearing columns

Beam

www.socomp.com

Column

www.goodrichlumber.com

Truss

http://info.buildabilitynow.com

Laminated Strand Lumber (LSL)

Similar to PSL, laminated strand lumber is made from flaked wood strands that have a length-to-thickness ratio of approximately 150. Combined with an adhesive, the strands are oriented and formed into a large mat or billet and pressed.

www.apawood.org

www.dataholz.com

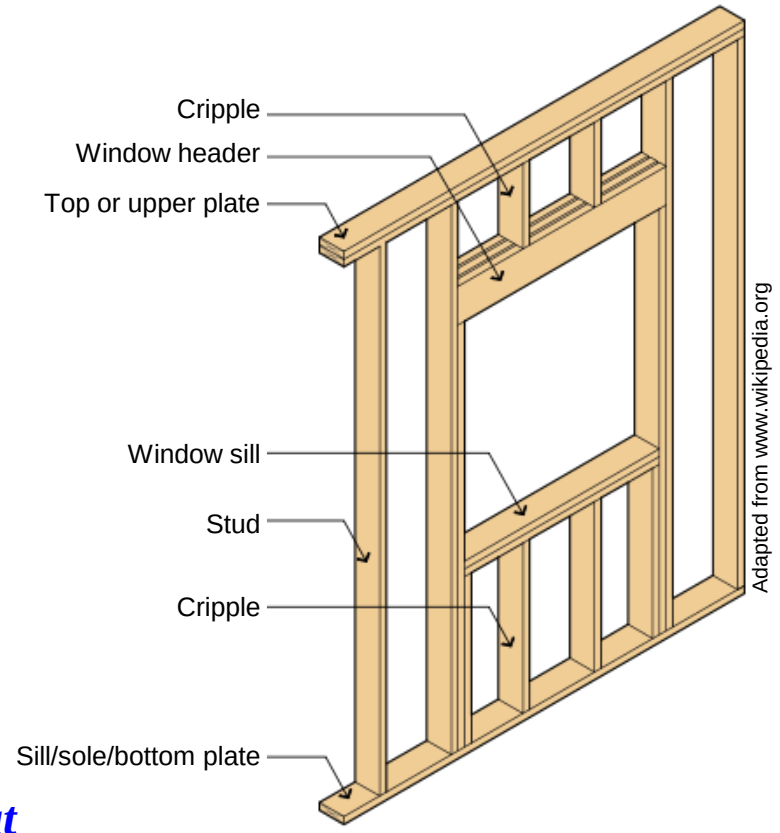
Oriented Strand Lumber (OSL)

Similar to LSL, oriented strand lumber is also made from flaked wood strands. The strand geometry for OSL results in length-to-thickness ratios of approximately 75. Combined with an adhesive, the strands are oriented and formed into a large mat or billet and pressed. OSL is used in a variety of applications from ***studs*** to ***millwork*** components

www.apawood.org

Uses of OSL

- Studs
- Beams
- Headers
- Rim boards
- Millwork components
- Trusses



A typical wall section in platform framing

The strands used in OSL are shorter than that used in LSL. Both LSL and OSL offer good fastener-holding strength.

Types of engineered wood products

Strands based
- Oriented strand board
- Parallel strand lumber
- Laminated strand lumber
- Oriented strand lumber

Particle based
- Particle board

Veneer based
- Plywood
- Laminated veneer lumber
- Overlaid products

Lumber based
- Glued laminated timbers
- Cross laminated timber
- Finger-joined lumber
- Edge glued products

Combinations
- I-Joists
- Structurally insulated panels

Fiber based
- Fiber reinforcement
- Wood plastic composites
- Medium density fiber board
- Hardboard or high density fiber board

Particle based EWP

Particle board

Particle board, also known as particleboard and chipboard, is a wood product made from chips of wood or sawdust. It is mixed with resin or glue (both adhesives), then, under pressure and heat, pressed into uniform sheets

Density: ca. 640-800 kg m^{-3}

Different types of particles used in particle board manufacturing

Bowyer JL, Shmulsky R, Haygreen JG (2007) Forest Products & Wood Science: An Introduction. 5th Edition. Blackwell Publishing Ltd., Oxford, United Kingdom

Uses of particle boards

- Furniture manufacturing
- Flooring (subflooring)
- Roofing
- Sound absorbing

www.particleboardchina.com

Types of engineered wood products

Strands

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- Parallel strand lumber
- Laminated strand lumber
- Oriented strand lumber

Particle based

- Particle board

Veneer based

- Plywood
- Laminated veneer lumber
- Overlaid products

Lumber based

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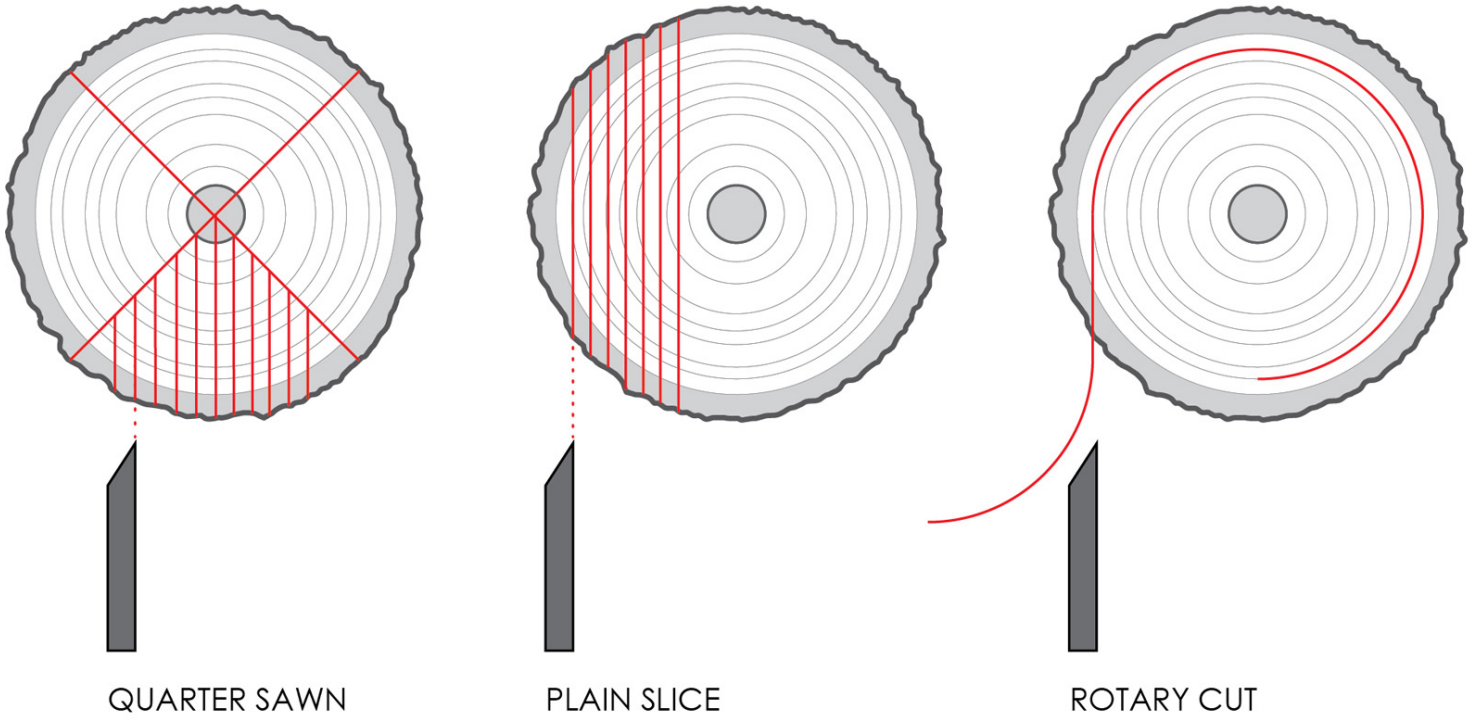
Venneer based EWP

Plywood

Plywood is a panel product consisting of thin wood veneers (plies) glued together so that the grain direction of each layer of veneer is perpendicular to that of the adjacent layers. This cross-lamination provides excellent two-way strength and stiffness properties, resistance to impact damage, and dimensional stability when gaining or losing moisture.



http://blog.buildllc.com/2013/10/veneering-101/

www.craftsmensupply.com

www.hitechveneer.com

www.woodworkerssource.com

http://davao-sm.all.biz

www.vicover.it

www.design42day.com

Furniture

www.nrcan.gc.ca

Construction

Parquet

Scaffold

Instrument

www.zdnet.com

Architectural design

Laminated veneer lumber (LVL)

LVL is an engineered wood product that uses multiple layers of thin wood assembled with adhesives. It is similar in appearance to plywood without crossbands.

Thickness of veneer: 2.5-3.2 mm

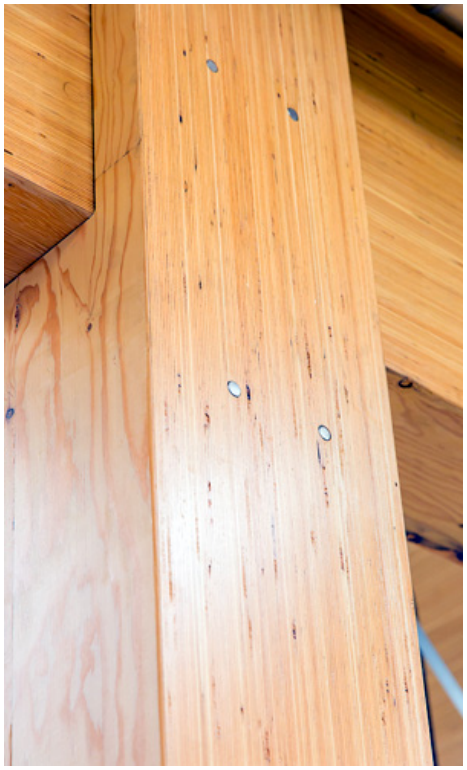
Uses of LVL

www.apawood.org

Beam

www.roseburg.com

Header



www.briscoman.com

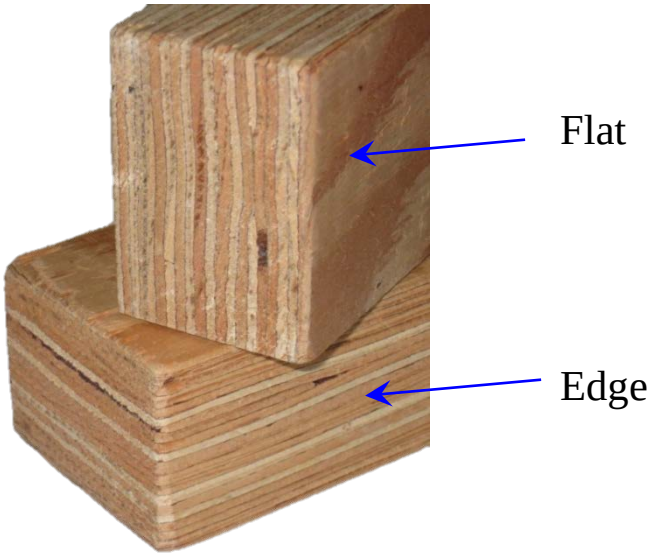
Column

www.redbuilt.com

www.timberdesignmag.com

Rafters

- Softwood veneers produced as in plywood production
- Veneers graded prior to assembly
- Higher quality veneers are placed on the outsides
- Veneers glued with grain running parallel to each other
- LVL used on flat or on edge



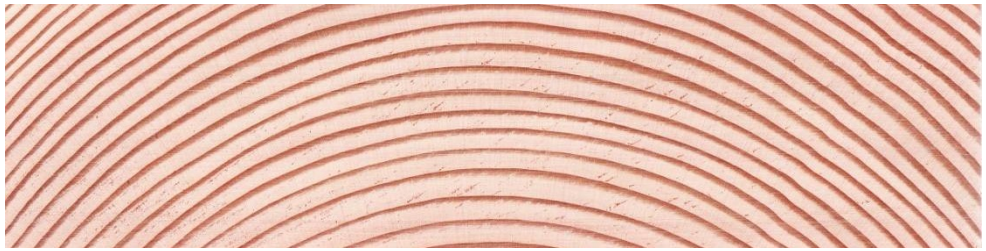
LVL – end use dimensions

Width	1 ½ in., 1 ¾ in, and 3 ½ in
Depth	up to 24 in
Length	up to 24 m

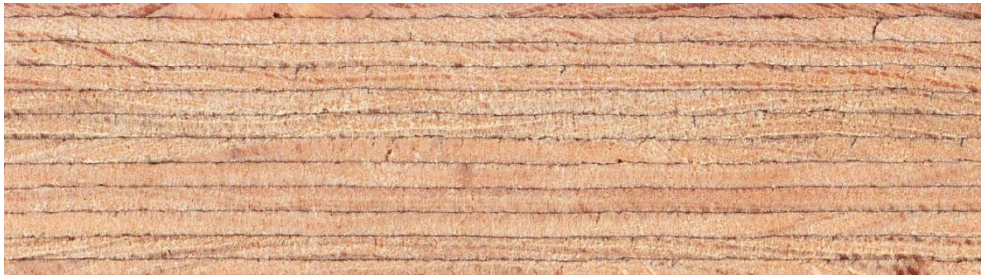
Adapted from www.wood120.forestry.ubc.ca

Reduction of natural variability

- Defects in veneer can be removed or dispersed
- Variability is reduced
- Yield of veneer from logs is higher than yield of solid lumber



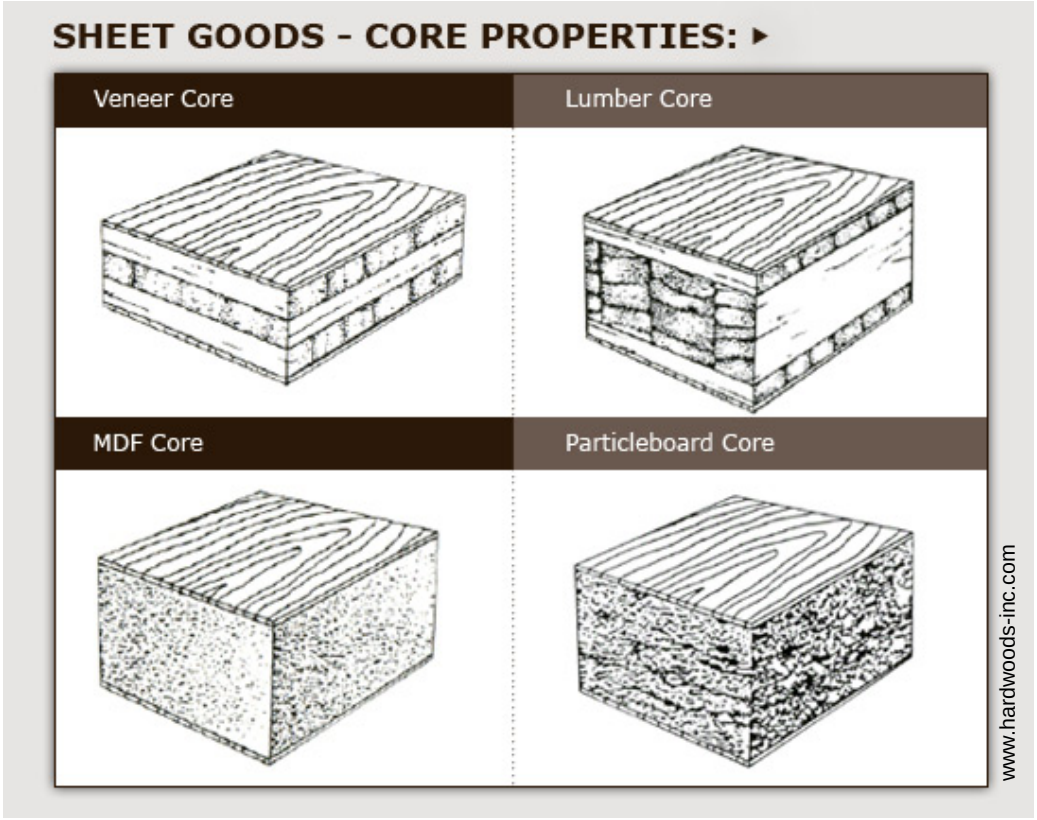
Solid wood
Variability at greatest level

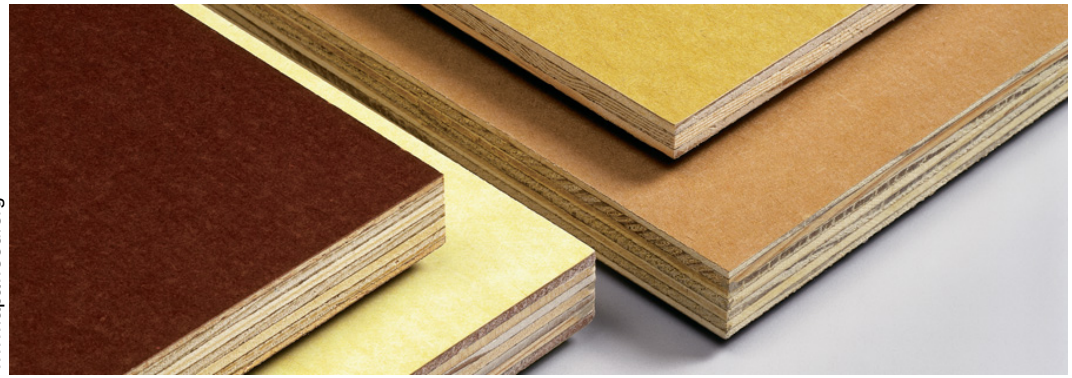


Laminated Veneer Lumber
Variability is reduced

Overlaid products

When substrate like MDF, HDF, plywood etc. is overlaid with thin layer of veneer with resin. Veneer could be natural or synthetic.





HDO/MDO plywood

Overlay paper

Plywood panel with decorative paper overlay

Block board

Types of engineered wood products

Strands
- Oriented strand board
- Parallel strand lumber
- Laminated strand lumber
- Oriented strand lumber

Particle based
- Particle board

Veneer based
- Plywood
- Laminated veneer lumber
- Overlaid products

Lumber based
- Glued laminated timbers
- Cross laminated timber
- Finger-joined lumber
- Edge glued products

Combinations
- I-Joists
- Structurally insulated panels

Fiber based
- Fiber reinforcement
- Wood plastic composites
- Medium density fiber board
- Hardboard or high density fiber board

Lumber based EWPs

Glued laminated timbers (glulam)

Is a type of structural timber product comprising a number of layers of dimensioned timber bonded together with durable, moisture-resistant structural adhesives. In North America the material providing the laminations is termed laminating stock or lamstock.

www.tranduchomes.org

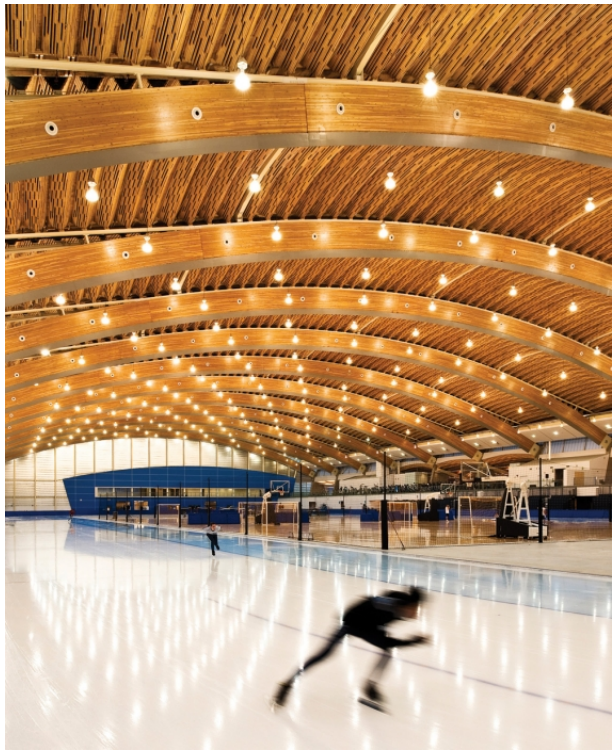
Uses of glulam

www.uslumber.com

Beam

www.wikipedia.org

Glulam bridge (Canada)

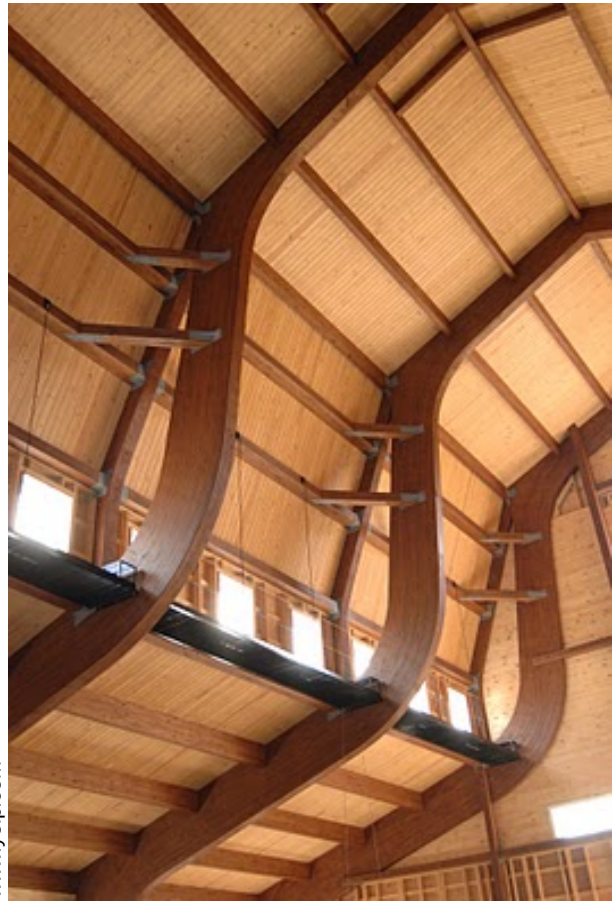


Richmond Olympic Oval (Canada)

www.solaripedia.com

www.archiexpo.com

Column



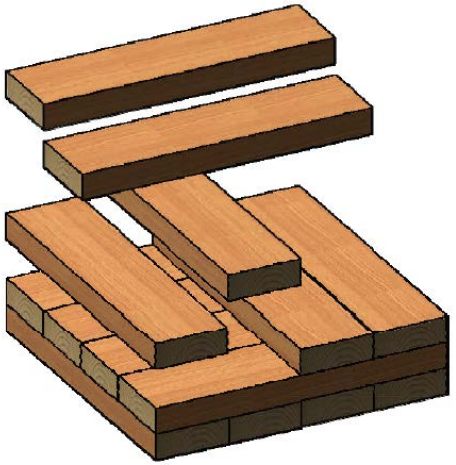
www.yelp.com

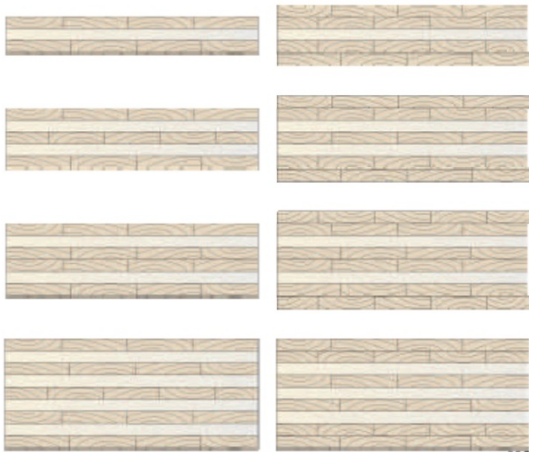
www.pinterest.com

Glulam – curved members

Cross laminated timbers (CLT)

CLT consist of several layers of structural lumber boards stacked crosswise (typically at 90 degrees). It is also known as ***massive timber***.





Mohammad et al. (2012) Wood Design Focus 22(2):3-12

Uses of CLT

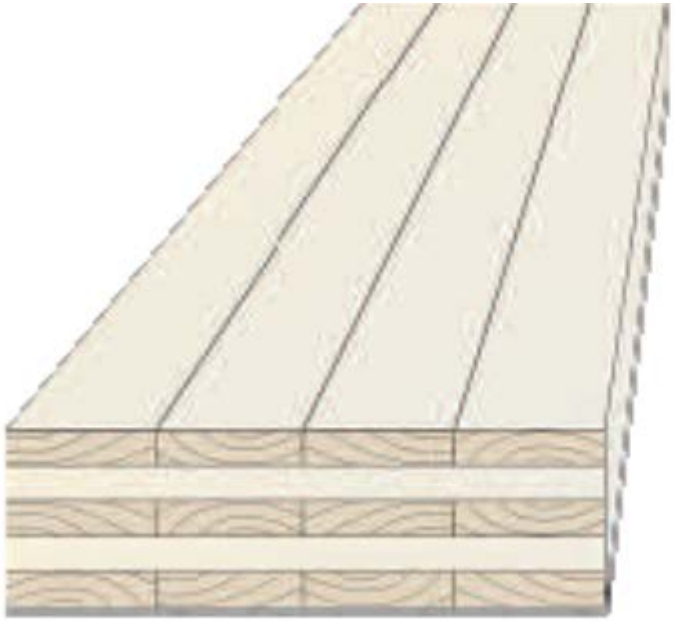
Commonly used for-

- Long spans in walls
- Floors
- Roofs etc.

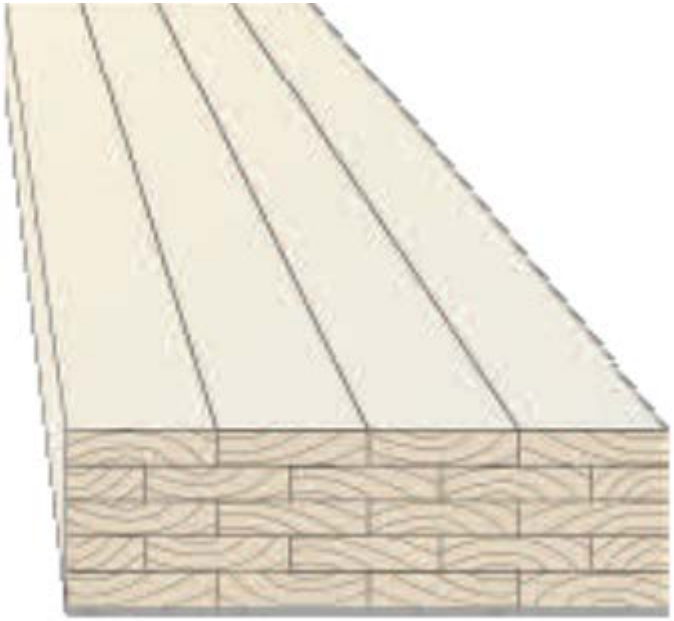
www. youtube.com

www.apawood.org

www. environdec.com



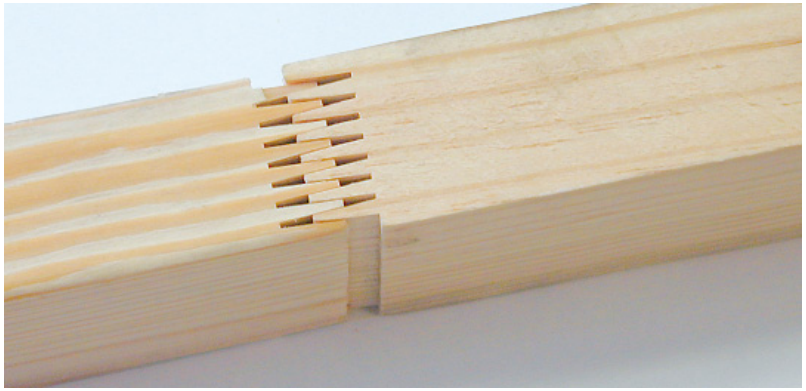
CLT



Glulam

Finger-joined lumber

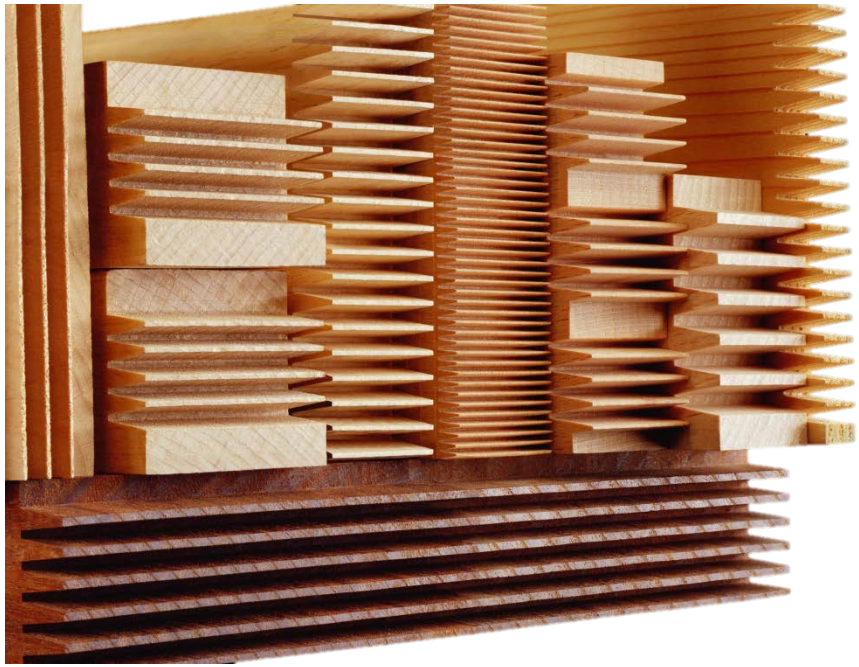
A finger joint is a woodworking joint made by cutting a set of complementary cuts in two pieces of wood, which are then glued. It is stronger than a butt joint or lap joint, and often contributes to the aesthetics (appearance) of the piece



www.lonestarstuds.com

www.reddit.com

Uses of finger-joined lumber



Different finger jointing lines

Glulam

Laminated pine board

Edge glued products

Made of finger jointed or solid wood lamellas (strips, flitches) glued together with adhesive.

Uses of edge glued panels

- Furniture panels
- Table tops
- Cutting boards
- Butcher blocks
- Bench tops
- Stool seats
- Important component of high quality furniture designs
- Residential constructions

Butcher block

Cutting board

Stool seat

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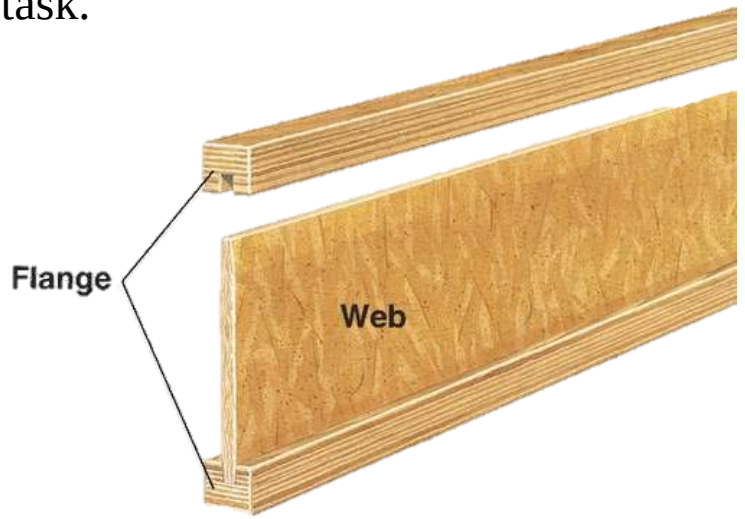
Combinations of EWPs

I-joist

"I"-shaped structural members designed for use in floor and roof construction. An I-joist consists of top and bottom flanges of various widths united with webs of various depths. The flanges resist common bending stresses, and the web provides shear performance. I-joists are designed to carry heavy loads over long distances while using less lumber than a dimensional solid wood joist of a size necessary to do the same task.

- Flange: LVL or solid sawn lumber
- Web: Plywood or OSB



Uses of I-joists

www.apawood.org

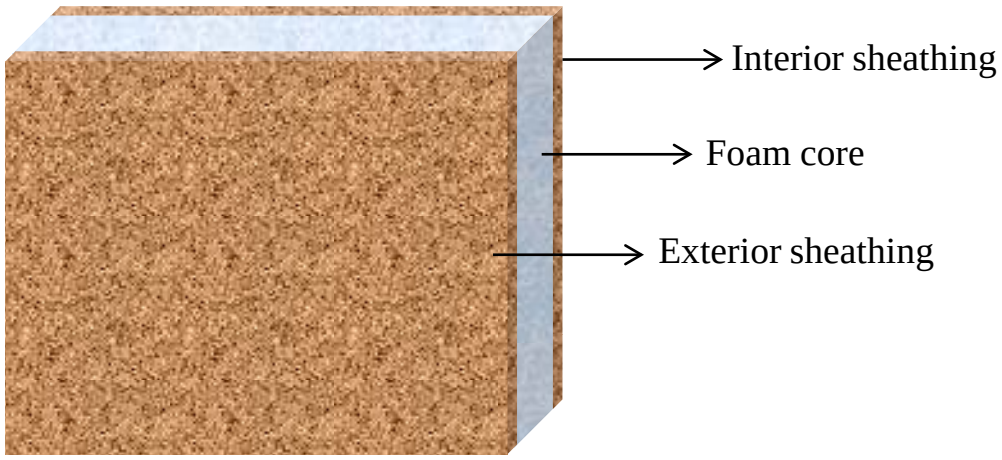
Roof framing

www.surehouse.org

Floor framing

Structurally insulated panels (SIPs)

SIPs consist of an insulating foam core sandwiched between two structural facings, typically oriented strand board (OSB).



Uses of SIPs

- Share the same structural properties as an I-beam
- The rigid insulation core of the SIP acts as a web, while the sheathing fulfills the function of the flanges
- Used for many different applications, such as exterior wall, roof, floor and foundation systems

www.buildipedia.com

Framing

Types of engineered wood products

Strands

- Oriented strand board
- Parallel strand lumber
- Laminated strand lumber
- Oriented strand lumber

Particle based

- Particle board

Veneer based

- Plywood
- Laminated veneer lumber
- Overlaid products

Lumber based

- Glued laminated timbers
- Cross laminated timber
- Finger-joined lumber
- Edge glued products

Combinations

- I-Joists
- Structurally insulated panels

Fiber based

- Fiber reinforcement
- Wood plastic composites
- Medium density fiber board
- Hardboard or high density fiber board

Fiber based EWPs

Fiber reinforced composite (FRC)

Fillers and reinforcement such as natural fibers embedded in or bonded to a matrix (polymer, cement etc.)

Enhance properties while lowering cost

Both matrix and fibers maintain their identity but produce a combination of properties not achievable by one component alone

www.materialicious.com

www.wikiedia .org

Uses of FRC

- Outdoor deck floors
- Railings
- Fences
- Landscaping timbers
- Cladding and siding
- Park benches
- Molding and trim
- Window and door frames
- Indoor furniture

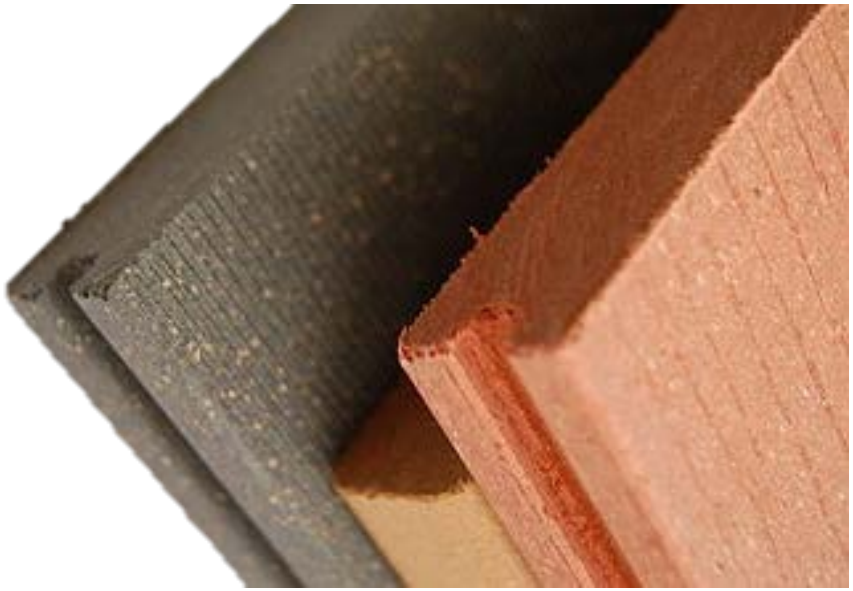
Interior designing

www.buildsabai.com

Fiber-cement composite tile

Wood plastic composites (WPC)

WPCs are composite materials made of wood fiber/wood flour and thermoplastic(s) (includes PE, PP, PVC etc.)



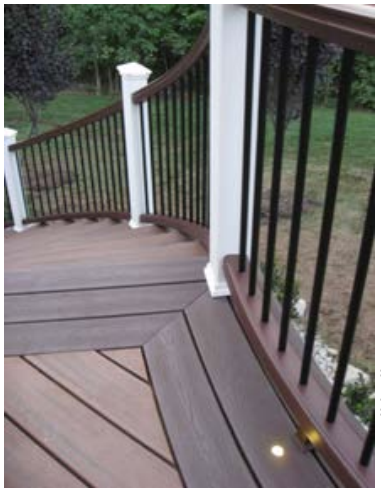
www.wikiedia .org

Uses of WPCs

- Outdoor deck floors
- Railings
- Fences
- Landscaping timbers
- Cladding and siding
- Park benches
- Window and door frames
- Indoor furniture

www.trade.indiamart.com

Window frame



www.wikiedia .org

Decking

www.de.made-in-china.com

Fence

www.pfi.no

Medium density fiber board (MDF)

MDF is an engineered wood product made primarily from wood fiber and bonded with synthetic resins. MDF is generally denser than plywood.

Density: ca. 500-800 kg m^{-3}

www.ifabstudio.com

www.3dmodular.co.uk

Uses of MDF

- Furniture
- Cabinetry
- Flooring
- Speaker boxes

www.familychristian.com

www.distinctivewoodproducts.com

www.joannasheen.com

High density fiber board (HDF)

HDF or hardboard. It is denser and much stronger and harder than particle board or MDF. Water soluble resins such PF are used.

Density: ca. 800–1040 kg m^{-3}

Uses of HDF

- Paneling
- Cabinet back
- Floor underlayment
- Home appliances
- Automobiles
- Cabinetry

www.menards.com

Wall panels

www.lumberjocks.com

Workbench

Thank you!!!