Description

Image


Caption

1. Close-up of the material. 2. Oak table. © Jia Design, UK

The material

Hardwoods come from broad leave, deciduous, trees such as oak, ash, elm, sycamore, mahogany. Although most hardwoods are harder than softwoods, there are exceptions: balsa, for instance, is a hardwood. Wood must be seasoned before it is used. Seasoning is the process of drying the natural moisture out of the raw timber to make it dimensionally stable, allowing its use without shrinking or warping. In air-seasoning the wood is dried naturally in covered but open-sided structure. In kiln-drying the wood is artificially dried in an oven or kiln. Modern kilns are so designed that an accurate control of moisture is achieved. Wood has been used for construction and to make products since the earliest recorded time. The ancient Egyptians used it for furniture, sculpture and coffins before 2500 BC. The Greeks at the peak of their empire (700 BC) and the Romans at the peak of theirs (around 0 AD) made elaborate buildings, bridges, boats, chariots and weapons of wood, and established the craft of furniture making that is still with us today. More diversity of use appeared in Mediaeval times, with the use of wood for large-scale building, and mechanisms such as pumps, windmills, even clocks, so that, right up to end of the 17th century, wood was the principal material of engineering. Since then cast iron, steel and concrete have displaced it in some of its uses, but timber continues to be used on a massive scale, particularly in housing and small commercial buildings.

Composition (summary)

Cellulose/Hemicellulose/Lignin/12%H2O

General properties

Density	53.1	-	64.3	lb/ft^3
Price	* 0.299	-	0.331	USD/lb
Date first used	-10000			

Mechanical properties

Young's modulus	2.99	-	3.65	10^6 psi
Shear modulus	* 0.218	-	0.261	10^6 psi
Bulk modulus	0.363	-	0.406	10^6 psi
Poisson's ratio	* 0.35	-	0.4	
Yield strength (elastic limit)	6.24	-	7.54	ksi
Tensile strength	19.1	-	23.5	ksi
Compressive strength	9.86	-	12	ksi
Elongation	* 1.7	-	2.1	% strain
Hardness - Vickers	* 13	-	15.8	HV
Fatigue strength at 10^7 cycles	* 6.09	-	7.54	ksi
Fracture toughness	* 8.19	-	9.1	ksi.in^0.5
Mechanical loss coefficient (tan delta)	* 0.005	-	0.009	

Thermal properties

Glass temperature		171	-	216	°F
Maximum service temperature		248	-	284	°F
Minimum service temperature	*	-148	-	-94	°F
Thermal conductor or insulator?		Good insulator			
Thermal conductivity	*	0.237	-	0.289	BTU.ft/h.ft^2.F
Specific heat capacity		0.396	-	0.408	BTU/lb.°F
Thermal expansion coefficient	*	1.39	-	5	µstrain/°F

Electrical properties

Electrical conductor or insulator?		Poor insulator			
Electrical resistivity	*	6e13	-	2e14	µohm.cm
Dielectric constant (relative permittivity)	*	5	-	6	
Dissipation factor (dielectric loss tangent)	*	0.1	-	0.15	
Dielectric strength (dielectric breakdown)	*	10.2	-	15.2	V/mil

Optical properties

Transparency	Opaque

Processability

Moldability	2	-	3
Machinability	5		

Eco properties

Embodied energy, primary production	*	1.06e3	-	1.18e3	kcal/lb
CO2 footprint, primary production	*	0.841	-	0.93	lb/lb
Recycle		✗			

Supporting information

Design guidelines

Wood offers a remarkable combination of properties. It is light, and, parallel to the grain, it is stiff, strong and tough - as good, per unit weight, as any man-made material except CFRP. It is cheap, it is renewable, and the fossil-fuel energy needed to cultivate and harvest it is outweighed by the energy it captures from the sun during growth. It is easily machined, carved and joined, and - when laminated - it can be molded to complex shapes. And it is aesthetically pleasing, warm both in color and feel, and with associations of craftsmanship and quality.

Technical notes

The values for the mechanical properties given for woods require explanation. Wood-science laboratories measure the mean properties of high-quality "clear" wood samples: small specimens with no knots or other defects; the data for woods in the Level 3 CES database is of this type. This is not, however, the data needed for design. All engineering materials have some variability in quality and properties. To allow for this design handbooks list "allowables" - property values that will be met or exceeded by, say, 99% of all samples (meaning the mean value minus 2.33 standard deviations). Natural materials like wood show greater variability than man-made materials like steel, with the result that the allowable values for mechanical properties may be only 50% of the mean. There is a second problem: structures made of wood are much larger than the wood-science test samples. They contain knots, shakes and sloping grain, all of which degrade properties. To deal with this the wood is "stress-graded" by visual inspection or by automated methods, assigning each piece a stress grading G between 0 and 100: a grading of G means that properties are further knocked down by the factor G/100. Finally, in building construction, there is the usual requirement of sound practice - an overall safety factor, typically 2.25. The result is that the permitted stress for design may be as low as 20% of the value quoted in wood-science tabulations. The data in this record is for oak of medium density, and lists wood-science ranges for the properties of clear wood samples.
Wood prices are quoted in Board Feet (BF). 1 BF is 144 cubic inches. Here we list prices in the usual $/kg.

Typical uses

Flooring; stairways, furniture; handles; veneer; sculpture, wooden ware; sash; doors; general millwork; framing- but these are just a few. Almost every load-bearing and decorative object has, at one time or another, been made from wood.

Links

Reference

ProcessUniverse

Producers