Description

Image



Caption

1. Close-up of the material. © Chris Lefteri 2. Skateboard made with plywood. © Chris Lefteri 3. Plywood used in the construction area.

The material

Plywood is laminated wood, the layers glued together such that the grain in successive layers are at right angles, giving stiffness and strength in both directions. The number of layers varies, but is always odd (3, 5, 7…) to give symmetry about the core ply - if it is asymmetric it warps when wet or hot. Those with few plies (3,5) are significantly stronger and stiffer in the direction of the outermost layers; with increasing number of plies the properties become more uniform. High quality plywood is bonded with synthetic resin. The data listed below describe the in-plane properties of a typical 5-ply.

Composition (summary)

Cellulose/Hemicellulose/Lignin/12%H2O/Adhesive

General properties

Density	43.7	-	49.9	lb/ft^3
Price	* 0.249	-	0.277	USD/lb
Date first used	1907			

Mechanical properties

Young's modulus	1	-	1.89	10^6 psi
Shear modulus	* 0.0725	-	0.29	10^6 psi
Bulk modulus	* 0.232	-	0.363	10^6 psi
Poisson's ratio	0.22	-	0.3	
Yield strength (elastic limit)	* 1.31	-	4.35	ksi
Tensile strength	1.45	-	6.38	ksi
Compressive strength	1.16	-	3.63	ksi
Elongation	2.4	-	3	% strain
Hardness - Vickers	3	-	9	HV

Fatigue strength at 10^7 cycles	*	1.02	-	2.32	ksi
Fracture toughness	*	0.91	-	1.64	ksi.in^0.5
Mechanical loss coefficient (tan delta)	*	0.008	-	0.11	

Thermal properties

Glass temperature		248	-	284	°F
Maximum service temperature	*	212	-	266	°F
Minimum service temperature	*	-148	-	-94	°F
Thermal conductor or insulator?		Good insulator			
Thermal conductivity		0.173	-	0.289	BTU.ft/h.ft^2.F
Specific heat capacity		0.396	-	0.408	BTU/lb.°F
Thermal expansion coefficient		3.33	-	4.44	µstrain/°F

Electrical properties

Electrical conductor or insulator?		Poor insulator			
Electrical resistivity		6e13	-	2e14	µohm.cm
Dielectric constant (relative permittivity)		6	-	8	
Dissipation factor (dielectric loss tangent)	*	0.05	-	0.09	
Dielectric strength (dielectric breakdown)	*	10.2	-	15.2	V/mil

Optical properties

Transparency	Opaque

Critical Materials Risk

High critical material risk?	No

Processability

Moldability	3	-	4	
Machinability	5			

Durability: water and aqueous solutions

Water (fresh)	Acceptable
Water (salt)	Acceptable
Soils, acidic (peat)	Limited use
Soils, alkaline (clay)	Unacceptable
Wine	Acceptable

Durability: acids

Acetic acid (10%)	Limited use
Acetic acid (glacial)	Limited use
Citric acid (10%)	Limited use
Hydrochloric acid (10%)	Limited use

Hydrochloric acid (36%)	Unacceptable
Hydrofluoric acid (40%)	Unacceptable
Nitric acid (10%)	Limited use
Nitric acid (70%)	Unacceptable
Phosphoric acid (10%)	Limited use
Phosphoric acid (85%)	Unacceptable
Sulfuric acid (10%)	Limited use
Sulfuric acid (70%)	Unacceptable

Durability: alkalis

Sodium hydroxide (10%)	Unacceptable
Sodium hydroxide (60%)	Unacceptable

Durability: fuels, oils and solvents

Amyl acetate	Limited use
Benzene	Limited use
Carbon tetrachloride	Limited use
Chloroform	Limited use
Crude oil	Limited use
Diesel oil	Acceptable
Lubricating oil	Acceptable
Paraffin oil (kerosene)	Acceptable
Petrol (gasoline)	Acceptable
Silicone fluids	Acceptable
Toluene	Acceptable
Turpentine	Acceptable
Vegetable oils (general)	Acceptable
White spirit	Acceptable

Durability: alcohols, aldehydes, ketones

Acetaldehyde	Acceptable
Acetone	Limited use
Ethyl alcohol (ethanol)	Acceptable
Ethylene glycol	Acceptable
Formaldehyde (40%)	Acceptable
Glycerol	Acceptable
Methyl alcohol (methanol)	Acceptable

Durability: halogens and gases

Chlorine gas (dry)	Unacceptable
Fluorine (gas)	Unacceptable

O2 (oxygen gas)	Unacceptable
Sulfur dioxide (gas)	Limited use

Durability: built environments

Industrial atmosphere	Limited use
Rural atmosphere	Acceptable
Marine atmosphere	Acceptable
UV radiation (sunlight)	Good

Durability: flammability

Flammability	Highly flammable

Durability: thermal environments

Tolerance to cryogenic temperatures	Limited use
Tolerance up to 150 C (302 F)	Acceptable
Tolerance up to 250 C (482 F)	Unacceptable
Tolerance up to 450 C (842 F)	Unacceptable
Tolerance up to 850 C (1562 F)	Unacceptable
Tolerance above 850 C (1562 F)	Unacceptable

Primary material production: energy, CO2 and water

Embodied energy, primary production	2.68e3	-	2.95e3	kcal/lb
CO2 footprint, primary production	1.35	-	1.48	lb/lb
Water usage	* 79.7	-	88.1	gal(US)/lb
Eco-indicator 95	39			millipoints/kg
Eco-indicator 99	272			millipoints/kg

Material processing: energy

Coarse machining energy (per unit wt removed)	* 94.9	-	105	kcal/lb
Fine machining energy (per unit wt removed)	* 486	-	537	kcal/lb
Grinding energy (per unit wt removed)	* 921	-	1.02e3	kcal/lb

Material processing: CO2 footprint

Coarse machining CO2 (per unit wt removed)	* 0.0657	-	0.0727	lb/lb
Fine machining CO2 (per unit wt removed)	* 0.337	-	0.372	lb/lb
Grinding CO2 (per unit wt removed)	* 0.638	-	0.705	lb/lb

Material recycling: energy, CO2 and recycle fraction

Recycle	✗			
Recycle fraction in current supply	1	-	2	%
Downcycle	✓			
Combust for energy recovery	✓			

Heat of combustion (net)	* 2.14e3	-	2.31e3	kcal/lb
Combustion CO2	* 1.69	-	1.78	lb/lb
Landfill	✓			
Biodegrade	✓			
Toxicity rating	Non-toxic			
A renewable resource?	✓			

Environmental notes

Wood is a renewable resource, absorbing CO2 as it grows. Present day consumption for engineering purposes can readily be met by controlled planting and harvesting, making wood a truly sustainable material.

Supporting information

Design guidelines

Plywoods offers high strength at low weight. Those for general construction are made from softwood plys, but the way in which plywood is made allows for great flexibility. For aesthetic purposes, hardwoods can be used for the outermost plys, giving "paneling plywoods" faced with walnut, mahogany or other expensive woods on a core of softwood. Those for ultra-light design have hardwood outer plys on a core of balsa. Metal-faced plywoods can be riveted. Curved moldings for furniture such as chairs are made by laying-up the unbonded plys in a shaped mold and curing the adhesive under pressure using an airbag or matching mold. Singly curved shapes are straightforward; double curvatures should be minimized or avoided.

Technical notes

Low cost plywoods are bonded with starch or animal glues and are not water resistant -- they are used for boxes and internal construction. Waterproof and marine plywoods are bonded with synthetic resin -- they are used for external paneling and general construction.

Typical uses

Furniture, building and construction, marine and boat building, packaging, transport and vehicles, musical instruments, aircraft, modeling.

Links

Reference

ProcessUniverse

Producers