

Selected Characteristics of Colorado Woods

Wood species	Paint-holding characteristic		Weathering		Heartwood		Resistance to splitting in nailing and screwing	Nail and screw holding ability	Ease of bonding	
	Oil based paint	Latex paint	Resistance to cupping	Decay resistance	Ease of treating	Color of heartwood				Ease of machining
Aspen	2	3	3	1	3	Pale brown	3	4	2	4
Douglas-fir	1	3	3	2	1	Pale red	3	3	4	3
Engelmann Spruce	2	3	3	1	2	White	3	4	2	4
Limber Pine				1						
Lodgepole Pine				1	2	Pale yellow	3	3	2	3
Pinon Pine				1	4					
Ponderosa Pine	2	3	3	1	4	Cream	4	4	2	4
Plains Cottonwood	2	3	1	1	3	White	1	4	2	2
Subalpine Fir	2	4	3	1	1	Pale tan	2	4	2	4
White Fir	2	4	3	1	2	White	2	4	3	4

Excellent 4 Very Good 3 Good 2 Fair 1

COLORADO WOOD UTILIZATION AND MARKETING ASSISTANCE CENTER

The Colorado Wood Utilization and Marketing Assistance Center is a collaborative between Colorado State University, the Colorado State Forest Service, and the US Forest Service. Its mission is to contribute to the improvement and maintenance of healthy forests conditions in Colorado through extension and outreach in the areas of wood science, forest products and business assistance. It was designed to help communities and businesses utilize the wood products made available from fuel reduction and forest restoration thinning activities in Colorado.

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Physical and Mechanical Properties (continued)

maximum crushing strength; compression perpendicular to grain is fiber stress at proportional limit; shear is maximum shearing strength; tension is maximum tensile strength; and side hardness is hardness measured when load is perpendicular to grain.

Most code requirements for wood interior finish materials are expressed in terms of flame spread index numbers. These values are determined in a standard fire test which evaluates the surface burning characteristics of a material. Different maximum flame spread indices are permitted depending upon building occupancy, location of the material in the building, and the presence of sprinklers.

Class	Flame Spread Range	Example Location
I or A	0-25	Enclosed vertical exits
II or B	26-75	Exit access corridors
III or C	76-200	Other rooms and areas

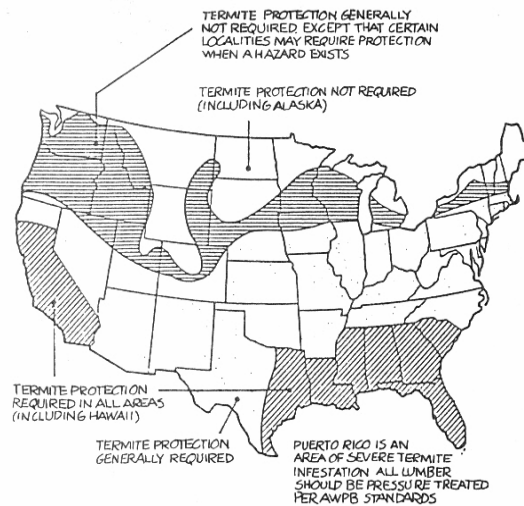
Working Properties: Engelmann spruce is easily worked.

Preservation: Engelmann spruce is resistant to preservative treatment.

Toxicity: In general, working with fresh spruce wood can cause dermatitis or other contact sensitivity.

Durability: The heartwood of spruce is slightly resistant to nonresistant to decay. The wood can be susceptible to attack by dry wood termites, ambrosia (pinhole borer) beetles, longhorn beetles, and Buprestid beetles.

Additional Information



The Wood Handbook: Wood as an Engineering Material, FPL-GTR-113. USDA Forest Products Laboratory, Madison, WI.

National Design Specification for Wood Construction. American Forest and Paper Association, Washington, DC.

Western Lumber Grading Rules. Western Wood Products Association, Portland, OR.

Product Use Guide

Engelmann Spruce

By David G. Bueche

“We may use wood with intelligence only if we understand wood.”

—Frank Lloyd Wright
In the Cause of Architecture: Wood
The Architectural Record
May 1928

Wood is used in many forms throughout the world. However, few people fully understand the properties and peculiarities that must be considered for optimum application. This publication was developed as an aid for furthering the understanding of wood. It is a compilation of scientific and trade names, tree and wood characteristics, including: weight; physical and mechanical properties; drying, shrinkage, and working properties; durability, preservation, toxicity, and uses for wood species native to Colorado.

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Colorado Woods

Engelmann Spruce

Picea engelmannii

Description

The word *picea* comes from the ancient Latin name (*pix, picis* = pitch) of a pitchy pine. The word *engelmannii* is named for George Engelmann (1809–1884), German born physician and botanist of St. Louis, who first recognized this species as not previously described.

The Tree: Engelmann spruce trees commonly reach heights of 130 ft with diameters of 3 ft.

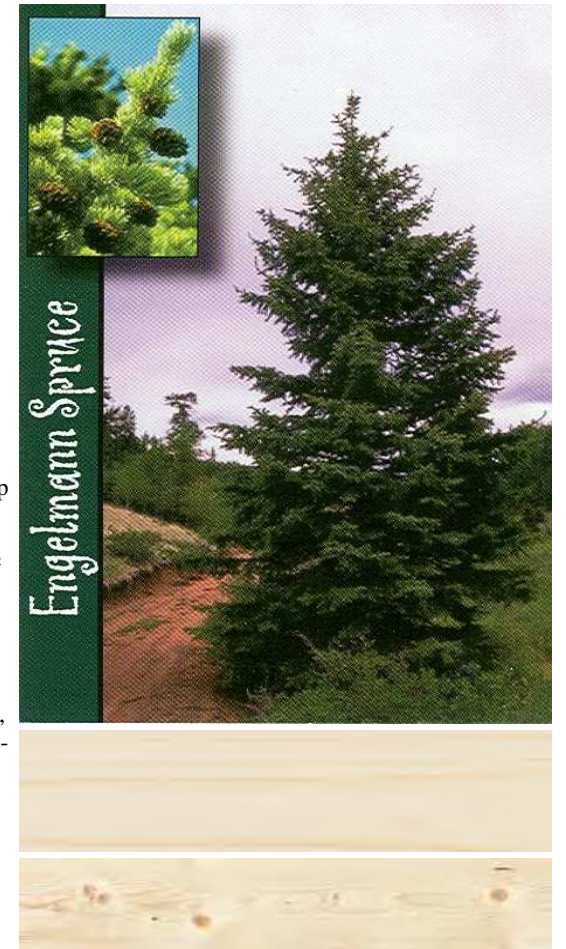
Bark: Gray-brown, thin, with flaky scales.

Leaves: Evergreen needles are deep blue-green with white lines, 5/8 to 1 inch long; slender, sharp and flexible; skunk-like odor when crushed.

Fruit: Light chestnut-colored, oblong cones; 1½ to 2½ inches long; in upper part of crown with scales that are paper thin and ragged along the outer edge. Seeds have a single, long and well-developed wing.

Habitat: High, cold forest environment on moist, northern slopes; with subalpine fir and other conifers.

Relation to Fire: Generally killed by fire due to thin bark, shallow roots, low growing branches, tendency to grow in dense stands and support heavy lichen growth. Large trees may survive low-intensity fires.



General Wood Characteristics

Wood nearly white to pale yellowish brown (heartwood not distinct), lustrous, without characteristic odor or taste, even- and usually straight grained with medium- to fine-texture. The sapwood varies from 0.75 to 2 in. in width and is often difficult to distinguish from heartwood. Engelmann spruce is low in strength as a beam or post. It is limber, soft, low in shock resistance, and has moderately small shrinkage. The lumber typically con-

tains numerous small knots. Growth rings are distinct, delineated by the contrast between the late wood and the early wood of the succeeding ring, narrow to wide. Early-wood zone usually a number of times wider than the late wood, grading into the late wood; late-wood zone distinct to the naked eye but usually not pronounced, somewhat darker than the early wood, generally narrow.



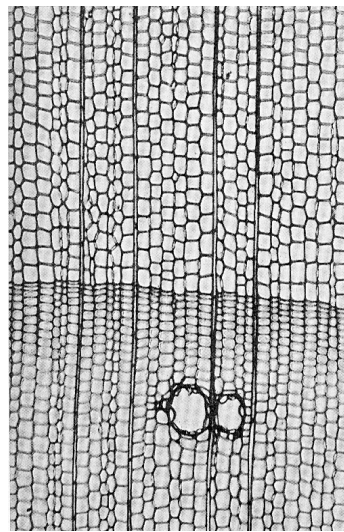
Uses

Pulpwood (principal use), reduced mainly by the sulfite and mechanical processes, and converted into a wide range of papers (from newsprint to high-grade writing paper); *fiber molded products*; *insulating boards*; *hardboard*; *particle board*; *round timbers* (poles, mine props); *railroad ties*; *cooperage* (staves and headings); *lumber* used for *boxes and crates* (very satisfactory in every way except when exceptionally high nail-holding capacity is required); *pallets*; *general building purposes* (boards, planks, joists, dimension stock); *planing-mill products* (doors, sash, casing, interior finish, roof decking, paneling); *laminated timbers*; *railroad*

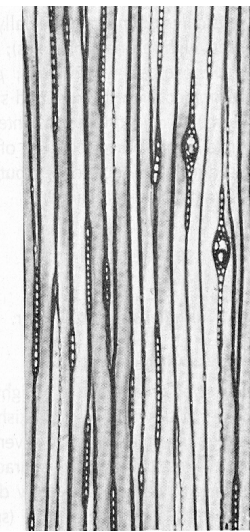
car construction and repairs; *boatbuilding*; *musical instruments*, especially for sounding boards (long a favorite because of its high resonant qualities); *furniture and kitchen cabinets*; *woodenware and novelties*; *ladder rails*; *paddles and oars* (because of its lightness combined with the required stiffness and strength); *veneer for containers*; *structural and prefinished interior plywood* on a limited scale (because of the scarcity of peeler-grade logs it seldom is used for rotary-cut veneer, but is considered to be excellent for production of cants for sliced veneer).

Minute Anatomy

Tracheids up to 35 (avg 25-30) μm in diameter; bordered pits in 1 row or very rarely paired on the radial walls; tangential pitting present in the last few rows of late-wood tracheids; pits leading to ray parenchyma piceoid, small, quite uniform in size, with distinct border, 1-6 (generally 2-4) per cross field, generally in a single horizontal row. Longitudinal parenchyma wanting. Rays of 2 types, uniseriate or rarely in part biseriate, and fusiform; (a) uniseriate rays numerous (t), 1-20 plus cells in height, biseriate rays very sparse and scattered, or wanting; (b) fusiform rays scattered, with 1 or rarely 2 transverse resin canals, 2-3-seriate through the central thickened portion, tapering above and below to uniseriate margins like the (a) rays, up



x—75x



t—75x

to 20 plus cells in height; end walls nodular, with indentures; ray tracheids in both types of rays, usually restricted to 1 row on the upper and lower margins, nondentate; cross sections of some of the ray tracheid pit borders distinctly thickened, ridged, or spurred on the cell lumen side and bluntly angled to the pit aperture. Resin canals with thick-walled epithelium, occasionally with tylosoids in the heartwood; longitudinal canals with maximum diameter of 135 (avg 50-90) μm ; transverse canals much smaller (usually less than 30 μm). Spruce wood is sometimes confused with that of the true firs (*Abies* spp.) but can be readily separated from it by resin canals of the normal type which do not occur in

Drying and Shrinkage

Wood shrinks as it dries, and swells as it absorbs moisture. Dimensional changes generally take place from 0% to 28% moisture content, based on its oven-dry weight. In a dry atmosphere, wet or "green" wood loses moisture in the form of water vapor. Dry wood, on the other hand, absorbs moisture from a humid atmosphere. The moisture content of wood also may be increased by wetting with liquid water. If wet wood is put into place, it eventually dries to a moisture content in equilibrium with the water vapor pressure of the surrounding air. This is the equilibrium moisture content (EMC). This drying is accompanied by shrinkage. If wood has been dried too far below the moisture content reached in use, it absorbs water until the equilibrium moisture content is achieved, and swelling results.

When changes in moisture content are great and occur quickly, shrinkage and swelling may cause, not only dimensional changes, but also splitting, cracking, glue-line failures, or other defects in woodwork, furniture and other wood products. Small changes that take place slowly usually cause very small, hardly

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	7.1	5.3	2.2
Radial	3.8	2.7	1.1
Volumetric	11.0	8.3	3.5

noticeable dimensional changes. However, slight drying taking place over a fairly long period of time may generate cracks and distortions when wooden parts are severely restrained—for example, by mechanical fastenings such as staples, screws, nails, and bolts—so that shrinkage is inhibited. When drying stresses exceed the strength of either the wood itself or an adhesive bonding agent, failures will also occur, either in the wood itself or in the glue-lines.

Physical and Mechanical Properties

Property	Moisture Content		
	Green	(12%)	Ovendry
SG	0.33	0.35	0.35
Weight (lb/ft ³)	39	23	NA
MOE (lb/in ²)	1,030,000	1,300,000	—
MOR (lb/in ²)	4,170	9,300	—
C (lb/in ²)	2,180	4,480	—
C \perp (lb/in ²)	200	410	—
WML (in-lb/in ³)	5.1	6.4	—
Shear (lb/in ²)	640	1,200	—
Tension \perp (lb/in ²)	240	350	—
Toughness (in-lb)	150	110	—
Hardness (lb)	260	390	—
Conductivity (Btu•in/h•ft ² •°F)	—	0.75	0.63
Resistivity (h•ft ² •°F/Btu•in)	—	1.3	1.6
Heat of combustion (Btu/lb)	7780	9730	—
Flame Spread ASTM E-84	—	55	—

The values reported in this table are the results of tests on small clear specimens with moisture contents (MC) in the green, air-dry and oven-dry conditions. MC is the total amount of water in a given piece of wood and is expressed as a percentage of the oven-dry weight of the wood. The oven-dry weight is used as a basis because it is an indication of the amount of solid substance present. Solid wood substance is heavier than water, its specific gravity being about 1.5 regardless of species. Variation among species in the size of cells and in the thickness of cell walls affects the amount of solid wood substance present and, therefore, the specific gravity. Thus, specific gravity of wood is a measure of its solid wood substance and an index of its strength properties. Specific gravity is based on weight when oven-dry and volume when green or at 12% moisture content.

Definition of properties: Modulus of elasticity measured from a simply supported, center-loaded beam, on a span depth ratio of 14/1. To correct for shear deflection, the modulus can be increased by 10%. Impact bending is height of drop that causes complete failure, using 0.71-kg (50-lb) hammer; compression parallel to grain is also called

Continued on next page

Design Values for Visually Graded Structural Lumber

Englemann Spruce		Extreme fiber in bending, "F _b "		Tension parallel to grain, "F _t "	Horizontal shear, "F _v "	Compression perpendicular to grain, "F _{c\perp"}	Compression parallel to grain, "F _c "	Modulus of elasticity, "E"
Commercial grade	Size classification	Single member uses	Repetitive member uses					
Select structural		1350	1550	800	70	320	850	1,300,000
No.1		1150	1350	675	70	320	750	1,300,000
No.2	2" to 3" thick	950	1100	550	70	320	600	1,100,000
No.3	2" to 4" wide	525	600	300	70	320	375	1,000,000
Appearance		1150	1350	675	70	320	900	1,300,000
Stud		525	600	300	70	320	375	1,000,000
Construction	2" to 4" thick	700	800	400	70	320	675	1,000,000
Standard	4" wide	375	450	225	70	320	550	1,000,000
Utility		175	200	100	70	320	375	1,000,000
Select structural		1200	1350	775*	70	320	850	1,300,000
No.1		1000	1150	675*	70	320	750	1,300,000
No.2	2" to 4" thick	825	950	425*	70	320	625	1,100,000
No.3	5" and wider	475	550	250*	70	320	400	1,000,000
Appearance		1000	1150	675*	70	320	900	1,300,000
Stud		475	550	250*	70	320	400	1,000,000
Select structural		1050	—	700	65	320	675	1,100,000
No.1	Beams and Stringers	875	—	600	65	320	550	1,100,000
No.2		575	—	275	65	320	350	900,000
Select structural		975	—	650	65	320	700	1,100,000
No.1	Posts and Timbers	800	—	525	65	320	625	1,100,000
No.2		450	—	300	65	320	275	900,000
Select		—	1400	(Surfaced at 15% maximum MC and used at 15% maximum MC)	—	—	—	1,300,000
Commercial	Decking	—	1200		—	—	—	1,200,000

The design values listed were reproduced from *Design Values for Wood Construction*, a supplement to the 1986 edition of the *National Design Specification for Wood Construction* by the American Forest and Paper Association (AFPA). This supplement is revised periodically, so the designer should check with AFPA for the latest information.

Design values listed are for normal loading conditions.

Surfaced dry or surfaced green; used at 19% maximum MC.

The design values shown are applicable to lumber that will be used under dry conditions such as in most covered structures. For 2" to 4" thick lumber, the dry surfaced size shall be used. In calculating design values, the natural gain in strength and stiffness that occurs as lumber dries has been taken into consideration as well as the reduction in size that occurs when unseasoned lumber shrinks. The gain in load-carrying capacity due to increased strength and stiffness resulting from drying more than offset the design effect of size reduction due to shrinkage. For 5" and thicker lumber, the surfaced sizes also may be used because design values have been adjusted to compensate for any loss in size by shrinkage which may occur.

*Tabulated tension parallel to grain values for 5" and wider, 2 to 4" thick size classification apply to 5" and 6" widths only. For lumber wider than 6" the tabulated "F_t" values

shall be multiplied by the following:

Grade	Multiply Tabulated F _t Values by	
	8" and wider	10" and wider
Select Structural	0.90	0.80
No.1, No.2, No.3, & Appearance	0.80	0.60
Stud	—	—

Design values for Stud grade in 5" and wider size classifications apply to 5" and 6" widths only.

Values for F_b, F_t, and F_v for the grades of Construction, Standard, and Utility apply only to 4" widths. Design values for 2" and 3" widths of these grade are available from the Western Wood Products Association (WWPA).

The values in the table for dimension lumber 2 to 4" in thickness are based on edgewise use. When such lumber is used flatwise, the design values for extreme fiber in bending may be multiplied by the factors in the table to the right.

Dimension Lumber Used Flatwise	Thickness (in.)		
	2	3	4
Width			
2 in. to 4 in.	1.10	1.04	1.00
5 in. and wider	1.22	1.16	1.11

The design values for F_b for decking may be increased by 10% for 2" thick and 4% for 3" thick decking.

When 2" to 4" thick lumber is manufactured at a maximum MC of 15% and used in a condition where the MC does not exceed 15%, the design values may be multiplied by the following factors: F_b, 1.08; F_t, 1.08; F_v, 1.05; F_{c \perp} , 1.00; F_c, 1.17; and E, 1.05.

When 2" to 4" thick lumber is designed for use where the MC will exceed 19% for an extended period of time, design values shall be multiplied by the following: F_b, 0.86; F_t, 0.84; F_v, 0.97; F_{c \perp} , 0.67; F_c, 0.70; and E, 0.97.

When lumber 5" and thicker is designed for use where the MC will exceed 19% for an extended period of time, the design values shall be multiplied by the following factors: F_b, 1.00; F_t, 1.00; F_v, 1.00; F_{c \perp} , 0.67; F_c, 0.91; and E, 1.00.

When split, check or shake is absent from wide face of lumber, F_v may be multiplied by a factor of 2.00. When length of split, check or shake on wide face of lumber is known and no increase in them is anticipated, see NDS supplement for additional adjustments.

Stress rated boards of nominal 1", 1½" and 1½" thickness, 2" and wider are permitted design values shown for Select Structural, No. 1, No. 2, No. 3, Construction, Standard, Utility, and Appearance grades as shown in the 2" to 4" thick category when graded in accordance with stress rated board provisions in the grading rules (see WWPA).

When Decking graded to WWPA rules is surfaced at 15% maximum MC and used where the MC will exceed 15% for an extended period of time, the tabulated design values for Decking shall be multiplied by the following factors: F_b, 0.79; E, 0.92.

When the depth of a rectangular sawn lumber member 5" or thicker exceeds 12", the design value for F_b shall be multiplied by the size factor, C_F, as determined by the following formula: C_F = (12/d)^{1/9}.