

## **BENDING STRENGTH:**

Also known as modulus of rupture (MOR), this is a measure of a specimen's strength before rupture. It can be used to determine a wood species' overall strength; unlike the modulus of elasticity which measures the wood's deflection, but not its ultimate strength. (That is to say, some species of wood will bow under stress, but not easily break.)

MOR is expressed in pounds-force per square inch ( $lb_f/in^2$ ) or kilopascals (kPa). This number is given for wood that has been dried to a 12% moisture content, unless otherwise noted.

## **ELASTICITY:**

In the most simple terms, the modulus of elasticity (MOE) measures a wood's stiffness, and is a good overall indicator of its strength. Technically it's a measurement of the ratio of stress placed upon the wood compared to the strain (deformation) that the wood exhibits along its length. MOE is expressed in pounds-force per square inch ( $lb_f/in^2$ ) or megapascals (MPa). This number is given for wood that has been dried to a 12% moisture content, unless otherwise noted.

**Weight:** Average oven-dry weight. Rankings based on pounds per cubic foot: < 33 = low (light); 33 to 43 = medium (moderately heavy); > 43 = high (heavy).

**Hardness:** Side hardness or ability to resist compression perpendicular to the grain. Rankings based on fiber stress at proportional limit in pounds per square inch (psi): < 850 = low (dents easily); 850 to 1250 = medium (moderate hardness); > 1250 = high (hard).

**Stiffness:** Elasticity or ability to resist bending stress. Rankings based on modulus of elasticity in million psi: < 1.25 = low (bends easily); 1.25 to 1.65 = medium (moderate stiffness); > 1.65 = high (stiff).

**Bending Strength:** Maximum bending stress before failure occurs. Rankings based on modulus of rupture in psi: < 11000 = low (weak); 11000 to 14000 = medium (moderately strong); > 14000 = high (strong).

**Shock Resistance:** Impact strength or toughness. Measured by dropping a 50 pound hammer on a board supported on both ends at successively increasing heights until complete rupture occurs. Rankings based on max height of hammer in inches: < 30 = low; 30 to 55 = medium; > 55 = high.

**Stability:** Dimensional stability in service associated with changes in humidity levels. Rankings based on average seasonal movement of kiln-dried wood: low (not stable); medium (fairly stable); high (very stable).

**Working ease:** How easily the wood is worked. These rankings are somewhat more subjective than those for the other criteria but they take into account things such as blunting effects on cutting edges and how easily the wood splinters, chips, and burns. Rankings: low (works with difficulty); medium (works fairly easily); high (works easily).

# Yellow Birch *Betula alleghaniensis*

## Appearance

**COLOR:** In yellow birch (*B. alleghaniensis*), sapwood is creamy yellow or pale white; heartwood is light reddish brown tinged with red. In sweet birch (*B. lenta*), sapwood is light colored and heartwood is dark brown tinged with red.

**GRAIN:** Medium figuring, straight, closed grain, even texture. Occasional curly grain or wavy figure in some boards.

## Properties

**SIDE HARDNESS/JANKA:** 1260 (2% softer than Northern red oak).

**DIMENSIONAL STABILITY:** 10% less stable than Northern red oak

Radial	7.3
Tangential	9.5
Volumetric	16.8
T/R Ratio	1.3

**MODULUS OF RUPTURE:** 16,600 lbf/in<sup>2</sup> @12%

**MODULUS OF ELASTICITY:** 2.01x 10<sup>6</sup> lbf/in<sup>2</sup>@ 12%

Category	Green	Dry	Units
Weight		43	lbs/cu.ft.
Stiffness	1500	2010	1000 psi
Bending Strength	8300	16600	psi
Shearing Strength			1880 psi
Max. Crushing Strength	3380	8170	psi
Work to Maximum Load	16	21	in-lbs/in <sup>3</sup>

## Workability:

**SAWING/MACHINING:** Difficult to work with hand tools, but good machining qualities.

**NAILING:** No known problems.

Origin: North America.

Availability: Moderately available.

Dimensions: **2 1/4, 3 1/4**

Category availability: Solids

# Brazilian Cherry/Jatoba *Hymenaea courbaril*

## Appearance

**COLOR:** Sapwood is gray-white; heartwood is salmon red to orange-brown when fresh and becomes russet or reddish brown when seasoned; often marked with dark streaks.

**GRAIN:** Mostly interlocked; texture is medium to rather coarse.

**VARIATIONS WITHIN SPECIES AND GRADES:** Moderate to high color variation.

## Properties

**HARDNESS (JANKA):** Average of 2820 (119% harder than Northern red oak).

**DIMENSIONAL STABILITY:** Average (8.5; 1% more stable than Northern red oak). However, actual installations have shown significant movement. Longer-than-normal acclimation time is recommended.

Category	Green	Dry	Units
Weight		56	lbs/cu.ft.
Stiffness	1843	2422	1000 psi
Bending Strength	12957	21020	psi
Shearing Strength		2470	psi
Max. Crushing Strength	5800	9510	psi
Work to Maximum Load	15	18	in-lbs/in <sup>3</sup>
Radial Shrinkage (G->OD)	5 %		
Tangential Shrink. (G->OD)	9 %		
Volumetric Shrink (G->OD)	13 %		

## Workability

**SAWING/MACHINING:** Sawing is difficult due to high density; requires frequent sharpening of tools. Planing is difficult due to interlocked grain. Can be machined to a smooth surface. Carbide tooling recommended. Blunting effect moderate.

**NAILING:** Due to hardness it is very important that the angle of penetration be adjusted carefully. If using a pneumatic nailer, the air pressure should be adjusted.

**SANDING:** Scratches are easily seen—each sanding

**Origin** South America.

Availability

Easily available.

Dimensions:

3, 3 ¼, 4

# Tigerwood *Astronium spp*

## Appearance

COLOR: the color is light golden brown to reddish brown with blackish brown streaks of variable spacing.

GRAIN: The grain is wavy, regularly interlocking and the texture is fine.

## Properties

HARDNESS (JANKA):

DIMENSIONAL STABILITY: Moves very little once seasoned. Average reported shrinkage values (green to overdry are 4.5% radial and 7.0% tangential)

	Green	Dry	Units
Weight	77		lbs/cu.ft.
Density (air-dry)		62	lbs/cu.ft.
Stiffness		2479	1000 psi
Bending Strength		19285	psi
Max. Crushing Strength		11020	psi
Radial Shrinkage (G->OD)		4 %	
Tangential Shrink. (G->OD)		7 %	

## Workability

SAWING/MACHINING: In general the wood is somewhat difficult to work. Moderate to severe blunting of effect on tools.

NAILING: pre boring possibly necessary for nailing

Origin South America.

Availability moderate

*Ipe Tabebuia spp*

Appearance

**COLOR:** Can vary from light yellowish tan with green overtones to almost blackish brown; exhibits a large range of coloration when freshly milled; darkens over time to medium to dark brown.

**GRAIN:** Fine to medium, straight to very irregular.

Properties

**HARDNESS (JANKA):** 3680 (185% harder than Northern red oak).

**DIMENSIONAL STABILITY:** Average (8.0; 7% more stable than Northern red oak).

	Green	Dry	Units	
Weight	62	lbs/cu.ft.		
Stiffness	2901	3129	1000 psi	
Bending Strength	22458	25963	psi	
Shearing Strength			2048	psi
Max. Crushing Strength	10312	13366	psi	
Work to Maximum Load	28	22	in-lbs/in <sup>3</sup>	
Radial Shrinkage (G->OD)		7 %		
Tangential Shrink. (G->OD)		8 %		
Volumetric Shrink (G->OD)		13 %		

Workability

**SAWING/MACHINING:** Difficult, especially with hand tools. Blunting effect moderate.

**NAILING:** Predrilling and hand-nailing may be preferred.

**COMMENTS:** Has been known to cause contact dermatitis.

Origin South America.

Availability Readily available.

# Cumaru *Dipteryx Spp.*

## Appearance

**COLOR:** Uniform light brown or yellowish brown..

**GRAIN:** Grain interlocked

## Properties

**HARDNESS (JANKA):** 3540

**DIMENSIONAL STABILITY:** radial 5.0% tangential 7.6% volumetric 12.0%

Bending Strength 170MPa

Modulus of elasticity 26610MPa

Max. Crushing Strength 103 MPa

## Workability

**SAWING/MACHINING:** The wood is difficult to saw and bore; where severely interlocked grain is not present the wood planes to a smooth surface. Because of high density and oily nature the wood glues poorly

**NAILING:** Good but preboring necessary

Origin

Brazil

# Hickory *Carya spp.*

## Appearance

**COLOR:** Pecan heartwood is reddish brown with dark brown stripes; sapwood is white or creamy white with pinkish tones. Hickory heartwood is tan or reddish; sapwood is white to cream, with fine brown lines.

**GRAIN:** Pecan is open, occasionally wavy or irregular. Hickory is closed, with moderate definition; somewhat rough-textured.

**VARIATIONS WITHIN SPECIES AND GRADES:** In both hickory and pecan, there are often pronounced differentiations in color between spring wood and summer wood. In pecan, sapwood is usually graded higher than darker heartwood. Pecan and hickory are traditionally mixed by flooring mills.

## Properties

**HARDNESS (JANKA):** 1820 (41% harder than Northern red oak). Pecan is slightly softer than true hickories.

**DIMENSIONAL STABILITY:** Average (8.9; 3% less stable than Northern red oak).

	Green	Dry	Units	
Weight	47	lbs/cu.ft.		
Hardness		1820	lbs	
Stiffness	1370	1730	1000	psi
Bending Strength	9800	13700	psi	
Shearing Strength			2080	psi
Max. Crushing Strength	3990	7850	psi	
Work to Maximum Load	15	14	in-lbs/in <sup>3</sup>	

## Workability

**SAWING/MACHINING:** Hickory's density makes it difficult to machine and work with hand tools.

**NAILING:** Has a tendency to split the tongues.

Origin

North America.

Availability

Readily available.

# Santos *Myroxylon balsamum*

## **Appearance**

COLOR: Dark reddish brown.

GRAIN: Striped figuring in quartersawn selections; texture is even and very fine.

VARIATIONS WITHIN SPECIES AND GRADES: Moderate color variation.

## **Properties**

HARDNESS (JANKA): 2200 (71% harder than

Northern red oak).

DIMENSIONAL STABILITY: Above average (6.2; 28% more stable than Northern red oak).

	Green	Dry	
Weight	58	lbs/cu.ft.	
Stiffness	2040	2431	1000 psi
Bending Strength	16864	21861	psi
Shearing Strength		2204	psi
Max. Crushing Strength	8220	11855	psi
Radial Shrinkage (G->OD)		4 %	
Tangential Shrink. (G->OD)		6 %	
Volumetric Shrink (G->OD)		10 %	

## **Workability**

SAWING/MACHINING: Moderately difficult due to hardness; carbide tooling recommended.

NAILING: No known problems. Nail holding ability reported as good.

COMMENTS: Some respiratory/allergic reaction potential.

Origin South America.

Availability Moderate-low.

# American Black Walnut *Juglans nigra*

## Appearance

**COLOR:** Heartwood ranges from a deep, rich dark brown to a purplish black. Sapwood is nearly white to tan. Difference between heartwood and sapwood color is great; some flooring manufacturers steam lumber to bleed the darker heartwood color into the sapwood, resulting in a more uniform color.

**GRAIN:** Mostly straight and open, but some boards have burlled or curly grain. Arrangement of pores is similar to hickories and persimmon, but pores are smaller in size.

**VARIATIONS WITHIN SPECIES AND GRADES:** Great variety of color and figure within species, as well as variation in color among boards, especially in lower grades and from material that isn't steamed prior to kiln-drying.

## Properties

**HARDNESS (JANKA):** 1010 (22% softer than Northern red oak).

**DIMENSIONAL STABILITY:** Average (7.8; 9% more stable than Northern red oak).

Radial	5.5	
Tangential	7.8	Used for across the width of board for flooring
Volumetric	12.8	Important to know for kiln process
T/R Ratio	1.4	

**MODULUS OF RUPTURE:** 14600 lbf/in<sup>2</sup> @12%

**MODULUS OF ELASTICITY:** 1.68 x 10<sup>6</sup> lbf/in<sup>2</sup>@ 12%

	Green	Dry	Units
Weight	58	40	lbs/cu.ft.
Stiffness	1480	1790	1000 psi
Bending Strength	9100	14800	psi
Shearing Strength			1370 psi
Max. Crushing Strength	4175	7680	psi
Work to Maximum Load	16	14	in-lbs/in <sup>3</sup>

## Workability

**SAWING/MACHINING:** Excellent machining qualities.

**NAILING:** No known problems.

**SANDING:** Sands satisfactorily.

**COMMENTS:** Frequently used as a highlight material for borders or other inlay techniques.

Origin North America.

# Cherry *Prunus serotina*

## Appearance

**COLOR:** Heartwood is light to dark reddish brown, lustrous; sapwood is light brown to pale with a light pinkish tone. Color darkens significantly with age.

**GRAIN:** Fine, frequently wavy, uniform texture. Distinctive flake pattern on true quartersawn surfaces. Texture is satiny, with some gum pockets.

**VARIATIONS WITHIN SPECIES AND GRADES:** Significant color variation between boards.

## Properties

**HARDNESS (JANKA):** 950 (26% softer than Northern red oak).

**DIMENSIONAL STABILITY:** Above average (7.1; 17% more stable than Northern red oak).

	Green	Dry	Units		
Weight	46	36	lbs/cu.ft.		
Stiffness	1380	1655	1000 psi		
Bending Strength		7900	13250	psi	
Shearing Strength				1700	psi
Max. Crushing Strength		3435	7865	psi	
Work to Maximum Load		13	11	in-lbs/in <sup>3</sup>	
Radial Shrinkage (G->OD)			4 %		
Tangential Shrink. (G->OD)			7 %		
Volumetric Shrink (G->OD)			12 %		

## Workability

**SAWING/MACHINING:** Good machining qualities.

**NAILING:** No known problems.

**Origin** North America.

**Availability** Readily available.

# Hard Maple *Acer saccharum*

## Appearance

**COLOR:** Heartwood is creamy white to light reddish brown; sapwood is pale to creamy white.

**GRAIN:** Closed, subdued grain, with medium figuring and uniform texture. Occasionally shows quilted, fiddleback, curly or bird's-eye figuring. Figured boards often culled during grading and sold at a premium.

Properties

**HARDNESS (JANKA):** 1450 (12% harder than Northern red oak).

**DIMENSIONAL STABILITY:** Average (9.9; 15% less stable than red oak).

	Green	Dry	Units
Weight	56	44	lbs/cu.ft.
Hardness			1450 lbs
Stiffness	1550	1830	1000 psi
Bending Strength		9400	15800 psi
Shearing Strength			2330 psi
Max. Crushing Strength		4020	7830 psi
Work to Maximum Load		13	16 in-lbs/in <sup>3</sup>
Radial Shrinkage (G->OD)			5 %
Tangential Shrink. (G->OD)			10 %
Volumetric Shrink (G->OD)			15 %

## Workability

**SAWING/MACHINING:** Density makes machining difficult.

**NAILING:** No known problems.

**SANDING:** Extra care must be taken during sanding and finishing, as sanding marks and finish lines are more obvious due to maple's density and light color. The species also burnishes, dulling fine paper and screens and making it difficult to cut out previous scratches.

**Origin** North America.

Availability Easily available. Figured grains have limited availability.

# Northern Red Oak *Quercus spp.*

## **Appearance**

COLOR: Heartwood and sapwood are similar, with sapwood lighter in color; most pieces have a reddish tone. Slightly redder than white oak.

GRAIN: Open, slightly coarser (more porous) than white oak. Plainsawn boards have a plumed or flared grain appearance; riftsawn has a tighter grain pattern, low figuring; quartersawn has a flake pattern, sometimes called tiger rays or butterflies.

## **Properties**

HARDNESS (JANKA): Northern: 1290 (benchmark).

DIMENSIONAL STABILITY: Northern: average (8.6).

	Green	Dry	Units
Weight	63	43	lbs/cu.ft.
Stiffness	1440	1775	1000 psi
Bending Strength	8750	14050	psi
Shearing Strength			1780 psi
Max. Crushing Strength	3665	6900	psi
Work to Maximum Load	15	15	in-lbs/in <sup>3</sup>
Radial Shrinkage (G->OD)		4 %	
Tangential Shrink. (G->OD)		8 %	
Volumetric Shrink (G->OD)		13 %	

## **Workability**

SAWING/MACHINING: Above average in all machining operations.

NAILING: No known problems.

Origin North America.

Availability Easily available.

