Reference Design Values for Visually Graded Southern Pine Dimension Lumber (2”-4” thick)* **								
Species and commercial grade	Size classification	Bending Fb	Tension parallel to grain Ft	Shear parallel to grain Fv	Compression perpendicular to grain Fc1	Compression parallel to grain Fc	Modulus of Elasticity E	Minimum Modulus of Elasticity Emin
Southern Pine								
Dense Select Structural	2”- 4” wide	3050	1650	175	660	2250	1900000	690000
Select Structural		2850	1600	175	565	2100	1800000	660000
Non-Dense Select Structural		2650	1350	175	480	1950	1700000	620000
No. 1 Dense		2000	1100	175	660	2000	1800000	660000
No.1		1850	1050	175	565	1850	1700000	620000
No.1 Non-Dense		1700	900	175	480	1700	1600000	580000
No.2 Dense		1700	875	175	660	1850	1700000	620000
No. 2		1500	825	175	565	1650	1600000	580000
No.2 Non-Dense		1350	775	175	480	1600	1400000	510000
No. 3 and Stud		850	475	175	565	975	1400000	510000
Construction	4” wide	1100	625	175	565	1800	1500000	550000
Standard		625	350	175	565	1500	1300000	470000
Utility		300	175	175	565	975	1300000	470000
Dense Select Structural	5”- 6” wide	2700	1500	175	660	2150	1900000	690000
Select Structural		2550	1400	175	565	2000	1800000	660000
Non-Dense Select Structural		2350	1200	175	480	1850	1700000	620000
No. 1 Dense		1750	950	175	660	1900	1800000	660000
No.1		1650	900	175	565	1750	1700000	620000
No.1 Non-Dense		1500	800	175	480	1600	1600000	580000
No.2 Dense		1450	775	175	660	1750	1700000	620000
No. 2		1250	725	175	565	1600	1600000	580000
No.2 Non-Dense		1150	675	175	480	1500	1400000	510000
No. 3 and Stud		750	425	175	565	925	1400000	510000
Dense Select Structural	8” wide	2450	1350	175	660	2050	1900000	690000
Select Structural		2300	1300	175	565	1900	1800000	660000
Non-Dense Select Structural		2100	1100	175	480	1750	1700000	620000
No. 1 Dense		1650	875	175	660	1800	1800000	660000
No.1		1500	825	175	565	1650	1700000	620000
No.1 Non-Dense		1350	725	175	480	1550	1600000	580000
No.2 Dense		1400	675	175	660	1700	1700000	620000
No. 2		1200	650	175	565	1550	1600000	580000
No.2 Non-Dense		1100	600	175	480	1450	1400000	510000
No. 3 and Stud		700	400	175	565	875	1400000	510000
Dense Select Structural	10” wide	2150	1200	175	660	2000	1900000	690000
Select Structural		2050	1100	175	565	1850	1800000	660000
Non-Dense Select Structural		1850	950	175	480	1750	1700000	620000
No. 1 Dense		1450	775	175	660	1750	1800000	660000
No.1		1300	725	175	565	1600	1700000	620000
No.1 Non-Dense		1200	650	175	480	1500	1600000	580000
No.2 Dense		1200	625	175	660	1650	1700000	620000
No. 2		1050	575	175	565	1500	1600000	580000
No.2 Non-Dense		950	550	175	480	1400	1400000	510000
No. 3 and Stud		600	325	175	565	850	1400000	510000
Dense Select Structural	12” wide	2050	1100	175	660	1950	1900000	690000
Select Structural		1900	1050	175	565	1800	1800000	660000
Non-Dense Select Structural		1750	900	175	480	1700	1700000	620000
No. 1 Dense		1350	725	175	660	1700	1800000	660000
No.1		1250	675	175	565	1600	1700000	620000
No.1 Non-Dense		1150	600	175	480	1500	1600000	580000
No.2 Dense		1150	575	175	660	1600	1700000	620000
No. 2		975	550	175	565	1450	1600000	580000
No.2 Non-Dense		900	525	175	480	1350	1400000	510000
No. 3 and Stud		575	325	175	565	825	1400000	510000

Reference Design Values for Visually Graded Southern Pine Dimension Lumber (2"-4" thick)* **								
Species and commercial grade	Size classification	Bending Fb	Tension parallel to grain Ft	Shear parallel to grain Fv	Compression perpendicular to grain Fc1	Compression parallel to grain Fc	Modulus of Elasticity E	Minimum Modulus of Elasticity Emin
Southern Pine		**(Surfaced Dry – Used in dry service conditions – 19% or less moisture content)**						
Dense Structural 86	2" & wider	2600	1750	175	660	2000	1800000	660000
Dense Structural 72		2200	1450	175	660	2000	1800000	660000
Dense Structural 65		2000	1300	175	660	2000	1800000	660000
Southern Pine		**(Surfaced Green – Used in any service condition)**						
Dense Structural 86		2100	1400	165	440	1300	1600000	580000
Dense Structural 72	2-1/2" & wider	1750	1200	165	440	1100	1600000	580000
Dense Structural 65	2-1/2"-4" thick	1600	1050	165	440	1000	1600000	580000
Mixed Southern Pine								
Select Structural	2"- 4" wide	2050	1200	175	565	1800	1600000	580000
No. 1		1450	875	175	565	1650	1500000	550000
No. 2		1300	775	175	565	1650	1400000	510000
No. 3 and Stud		750	450	175	565	950	1200000	440000
Construction	4" wide	1000	600	175	565	1700	1300000	470000
Standard		550	325	175	565	1450	1200000	440000
Utility		275	150	175	565	950	1100000	400000
Select Structural	5"-6" wide	1850	1100	175	565	1700	1600000	580000
No. 1		1300	750	175	565	1550	1500000	550000
No. 2		1150	675	175	565	1550	1400000	510000
No. 3 and Stud		675	400	175	565	875	1200000	440000
Select Structural	8" wide	1750	1000	175	565	1600	1600000	580000
No. 1		1200	700	175	565	1450	1500000	550000
No. 2		1050	625	175	565	1450	1400000	510000
No. 3 and Stud		625	375	175	565	850	1200000	440000
Select Structural	10" wide	1500	875	175	565	1600	1600000	580000
No. 1		1050	600	175	565	1450	1500000	550000
No. 2		925	550	175	565	1450	1400000	510000
No. 3 and Stud		525	325	175	565	825	1200000	440000
Select Structural	12" wide	1400	825	175	565	1550	1600000	580000
No. 1		975	575	175	565	1400	1500000	550000
No. 2		875	525	175	565	1400	1400000	510000
No. 3 and Stud		500	300	175	565	800	1200000	440000

*Reference Design Values Notes

1. **Lumber Dimensions.** Tabulated design values 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 dressed sizes shall be used regardless of the moisture content at the time of manufacture or use. 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 offsets the design effect of size reductions due to shrinkage.
2. **Spruce Pine.** To obtain recommended design values for Spruce Pine, multiply the appropriate design values for Mixed Southern Pine by the corresponding conversion factor shown below and round to the nearest 100,000 psi for E; to the nearest 10,000 psi for Emin; to the next lower multiple of 5 psi for Fv and Fc1; to the next lower multiple of 50 psi for Fb, Ft, and Fc if 1,000 psi or greater, 25 psi or otherwise.

	Bending Fb	Tension parallel to grain Ft	Shear parallel to grain Fv	Compression perpendicular to grain Fc1	Compression parallel to grain Fc	Modulus of Elasticity E and Emin
Conversion Factor	0.78	0.78	0.98	0.73	0.78	0.82

3. **Size Factor.** For sizes wider than 12", use size factors for Fb, Ft, and Fc specified for the 12" width. Use 100% of the Fv, Fc1, E, and Emin specified for the 12" width.
4. When individual species or species groups are combined, the design values to be used for the combination shall be the lowest design values for each individual species or species group for each design property.

**Adjustment Factors

Repetitive Member Factor, Cr. Bending design values, Fb, for dimension lumber 2” to 4” thick shall be multiplied by the repetitive member factor, Cr = 1.15, when such members are used as joists, truss chords, rafters, studs, planks, decking, or similar members which are in contact or spaced not more than 24” on center, are not less than 3 in number and are joined by floor, roof, or other load distributing elements adequate to support the design load.

Wet Service Factor, Cm. When dimension lumber is used where moisture content will exceed 19% for an extended time period, design values shall be multiplied by the appropriate wet service factors from the following table (for surfaced dry Dense Structural 86, Dense Structural 72, and Dense Structural 65 use tabulated surfaced green design values for wet service conditions without further adjustment):

Fb	Ft	Fv	Fc1	Fc	E and Emin
0.85*	1.0	0.97	0.67	0.8**	0.9

*when (Fb)(Cf) <= 1150 psi, Cm = 1.0, **when (Fc) <= 750 psi, Cm = 1.0

Size Factor, Cf. Appropriate size adjustment factors have already been incorporated in the tabulated design values for most thicknesses of Southern Pine and Mixed Southern Pine dimension lumber. For dimension lumber 4” thick, 8” and wider (all grades except Dense Structural 86, Dense Structural 72, and Dense Structural 65), tabulated bending design values, Fb, shall be permitted to be multiplied by the size factor, Cf = 1.1. For dimension lumber wider than 12” (all grades except Dense Structural 86, Dense Structural 72, and Dense Structural 65), tabulated bending, tension and compression parallel to grain design values for 12” wide lumber shall be multiplied by the size factor, Cf = 0.9. When the depth, d, of Dense Structural 86, Dense Structural 72, or Dense Structural 65 dimension lumber exceeds 12”, the tabulated bending design value, Fb, shall be multiplied by the following size factor: Cf = (12/d)^(1/9)

Flat Use Factor, Cfu. Bending design values adjusted by size factors are based on edgewise use (load applied to narrow face). When dimension lumber is used flatwise (load applied to wide face), the bending design value, Fb, shall also be multiplied by the following flat use factors:

Width (depth)	Thickness (breadth)	
	2” & 3”	4”
2” & 3”	1.0	----
4”	1.1	1.0
5”	1.1	1.05
6"	1.15	1.05
8”	1.15	1.05
10” & wider	1.2	1.1

Temperature Factor, Ct. When structural members will experience sustained exposure to elevated temperatures up to 150 deg. F, Reference design values shall be multiplied by the following:

Reference Design Values	In-Service Moisture Conditions	Ct		
		T <= 100 degF	100 degF<T<=125 degF	125 degF<T<=150 degF
Ft, E, Emin	Wet or Dry	1.0	0.9	0.9
Fb, Fv, Fc, and Fc1	Dry	1.0	0.8	0.7
	Wet	1.0	0.7	0.5

Load Duration Factor, Cd. When structural members will sustain loads for a design period which does not exceed the normal duration for the design load, typically a cumulative duration of approximately 10 years, all reference design values except modulus of elasticity, E, modulus of elasticity for beam and column stability, Emin, and compression perpendicular to grain, Fc1, based on deformation limit shall be multiplied by the appropriate load duration factor from the table below. The duration factor, Cd for the shortest duration load in a combination of loads shall apply for that load combination.

Load Duration	**Cd**	**Typical Design Loads**
Permanent	0.9	Dead Load
Ten years	1.0	Occupancy Live Load
Two months	1.15	Snow Load
Seven days	1.25	Construction Load
Ten minutes	1.6	Wind/Earthquake Load
Impact*	2.0	Impact Load

*Load duration factors greater than 1.6 shall not apply to structural members pressure-treated with water-borne preservatives, or fire retardant chemicals. The impact load duration factor shall not apply to connections.

Beam Stability Factor, CL. When the depth of a bending member does not exceed its breadth, d<=b, no lateral support is required and CL = 1.0. When the compression edge of a bending member is supported throughout its length to prevent lateral displacement, and the ends at points of bearing have lateral support to prevent rotation, CL = 1.0. When rectangular sawn lumber bending members are laterally supported as shown below, CL = 1.0.

(a) d/b<=2; no lateral support shall be required.
(b) 2<d/b<=4; the ends shall be held in position, as by full depth solid blocking, bridging, hangers, nailing, or bolting to other framing members, or other acceptable means.
(c) 4<d/b<=5; the compression edge of the member shall be held in line for its entire length to prevent lateral displacement, as by adequate sheathing or subflooring, and ends at point of bearing shall be held in position to prevent rotation and/or lateral displacement.
(d) 5<d/b<=6; bridging, full depth solid blocking or diagonal cross bracing shall be installed at intervals not exceeding 8 feet, the compression edge of the member shall be held in line as by adequate sheathing or subflooring, and the nds at points of bearing shall be held in position to prevent rotation and/or lateral displacement.
(e) 6<d/b<=7; both edges of the member shall be held in line for their entire length and ends at points of bearing shall be held in position to prevent rotation and/or lateral displacement.
(f) If bending member is subjected to flexure and axial compression then d/b<=5, and one edge must be firmly held in line.
(g) If under all combinations of load, the un-braced edge of the member is in tension then d/b<=6.

Bearing Area Factor, Cb. Compression design values perpendicular to grain, Fc1, apply to bearings of any length at the ends of a member, and to all bearings 6" or more in length at any other location. For bearing less than 6" in length and not nearer than 3" to the end shall be multiplied by the following bearing area factor, Cb = (lb + 0.375)/lb; where lb = the bearing length measured parallel to the grain in inches. For round bearing areas such as washer, the bearing length, lb, shall be equal to the diameter. The equation gives the following bearing area factors for the indicated bearing length on such small areas as plates and washers:

lb	0.5"	1"	1.5"	2"	3"	4"	6" or more
Cb	1.75	1.38	1.25	1.19	1.13	1.10	1.00

Buckling Length Coefficient Ke

End no. 1 (bottom)	**End no. 2 (top)**	**Design Ke**
Built-in: rotation fixed, translation fixed	Built-in: rotation fixed, translation fixed	0.65
Built-in: rotation fixed, translation fixed	Pinned: rotation free, translation fixed	0.80
Built-in: rotation fixed, translation fixed	Rotation fixed, translation free	1.20
Built-in: rotation fixed, translation fixed	Free: rotation free, translation free	2.10
Pinned: rotation free, translation fixed	Pinned: rotation free, translation fixed	1.0
Pinned: rotation free, translation fixed	Rotation fixed, translation free	2.4

Buckling Stiffness Factor, CT. Increased chord stiffness relative to axial loads when a 2"x4" or smaller sawn lumber truss compression chord is subjected to combined flexure and axial compression under dry service condition and has 3/8" or thicker plywood sheathing nailed to the narrow face of the chord in accordance with code required roof sheathing fastener schedules, shall be permitted to be accounted for by multiplying the reference modulus of elasticity design value for beam and column stability, Emin, by the buckling stiffness factor, CT, as calculated below:

When le < 96", CT = 1+(KMle)/(KTE); Where
le = effective column length of truss compression chord
KM = 2300 for wood seasoned to 19% moisture content or less at the time of plywood attachment.
KM=1200 for unseasoned or partially seasoned wood at the time of plywood attachment.

KT = 1.1645 (COVE)
KT = 0.59 for visually graded lumber
KT=0.75 for machine evaluated lumber (MEL)
KT = 0.82 for products with COVE<=0.11
When le>96”, CT shall be calculated based on le=96”.

Column Stability Factor, Cp. When a compression member is supported throughout its length to prevent lateral displacement in all directions, Cp = 1.0. For all other conditions Cp shall be calculated as follows:
Cp = (1+(FcE/Fc*))/2c – ((((1+(FcE/Fc*))/2c)^2 –(FcE/Fc*)/c)^0.5); where:
Fc* = reference compression design value parallel to grain multiplied by all applicable adjustment factors except Cp
Fce = (0.822Emin)/(le/d)^2
c = 0.8 for sawn lumber
c = 0.85 for round timber poles and piles
c = 0.9 for structural glued laminated timber or structural composite lumber

Incising Factor, Ci. Reference design values shall be multiplied by the following incising factor, Ci, when dimension lumber is incised parallel to grain a maximum depth of 0.4”, a maximum length of 3/8”, and density of incisions up to 1100/ft^2. Incising factors shall be determined by test or by calculation using reduced section properties for incising patterns exceeding these limits.

Design Value	**Ci**
E, Emin	0.95
Fb, Ft, Fc, Fv	0.80
Fc1	1.00