Western Lumber
Product Use Manual

Western Wood Products Association

BASE VALUES
for dimension lumber

Western Lumber Product Use Manual

ABOUT WWPA

Western Wood Products Association (WWPA) provides lumber grading and technical support services for the Western lumber products of its member mills. Approved by the Board of Review of the American Lumber Standard Committee, Inc. (ALSC), which operates under the jurisdiction of the U.S. Department of Commerce, WWPA is certified as a lumber inspection and rules-writing agency.

WWPA is approved to provide mill supervisory services and to grade and inspect lumber according to its own ***Western Lumber Grading Rules***, the West Coast Lumber Inspection Bureau's (WCLIB) ***West Coast Standard Grading Rules***, the Pacific Lumber Inspection Bureau's (PLIB) ***Export R List Rules***, the rules of the Redwood Inspection Service, the National Lumber Grades Authority's ***Standard Grading Rules for Canadian Lumber***, Eastern White Pine Common Board Grades of the Northeastern Lumber Manufacturers Association's ***Standard Grading Rules for Northeastern Lumber***, and the ***National Grading Rule*** portion of the ***Southern Pine Inspection Bureau Rules***. In addition, WWPA is approved to provide quality control and certification services for machine stress-rated (MSR) lumber and structural-glued lumber products in all Western species and heat treatment audit services under all ALSC recognized rules.

WWPA gradestamped National Grade Rule (NGR) Dimension lumber is recognized by the Japanese Ministry of Land, Infrastructure and Transportation for use in wood frame construction.

WWPA is certified to train mill graders to grade structural lumber to the Australian rules. In addition, WWPA gradestamped structural lumber is accepted for use in wood construction in Australia.

Lumber buyers may look to WWPA's registered grade mark for the assurance that lumber will consistently meet grade specifications and performance standards.

The Association maintains a team of Lumber Inspectors to monitor lumber grading and product quality control in its member mills and to provide mill inspection and grading performance reports, lumber grader training and incentive programs, MSR and glued products standards, resource recovery and mill efficiency studies.

In addition, WWPA provides technical and product support services and information on Western lumber end uses for lumber buyers throughout the world and publishes a variety of statistical reports on Western lumber production, distribution and consumption.

A host of Western lumber technical and product information is available online on the WWPA web site at **www.wwpa.org**. The site features an Online Lumber Technical Guide, an interactive Western Lumber Buyers Guide and digital versions of a number of WWPA literature titles.

DISCLAIMER

Information in this manual has been obtained by Western Wood Products Association from sources believed to be true. However, neither WWPA or its members, nor the authors guarantee the accuracy of any information published herein and these parties are not responsible for any errors, omissions or damages arising out of or relating to its use. This document is published with the understanding that WWPA, its members and the authors are supplying information, but are not attempting to render engineering or other professional services.

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WESTERN WOODS REGION

The West features a rich diversity of timber, with 231 million acres of forestland throughout the region. Of that acreage, just 126 million acres is available for commercial timber production and the remaining is reserved for wilderness, watershed protection, wildlife, parks and other non-commercial activities.

More than half of this timberland is owned by the federal government, which is managed by the U.S. Forest Service and Bureau of Land Management. The forest industry and other private landholders own 34 percent of this land and state and other public agencies account for the remaining 10 percent.

Recognizing the need for proper management and protection of the West's forest resources, timber companies and public agencies developed the first of the western forestland management laws in the early 1940s. The Oregon Forest Conservation Act of 1941 provided the framework for laws such as the Oregon Forest Practices Act, adopted in 1971. Other states, including Washington, California and Idaho, have adopted similar forest practices laws.

The evolution of these laws and improvements in forest management practices in the West has provided the foundation for some of the toughest, most progressive forest laws in the world. Ongoing private and publicly funded research has led to improvements in stream and watershed protection, fish and wildlife habitat, and other forest values important to society. The forest management practices used in the West today are designed to improve the whole forest ecosystem rather than for specific values.

While the federal government is the largest timberland owner in the West, the national forests supply just 7 percent of the timber processed by mills in the region today. The forest industry and other private owners account for some 78 percent of the timber cut into lumber.

Yet, according to the U.S. Department of Agriculture, private forest lands declined less than 0.5 percent from 1997 to 2002 while federal forest lands increased by 1 percent. Thanks to forest management regulations and efforts by the forest industry and other private landowners to practice sustainable forestry, the forests of the West will continue to supply the country's wood needs far into the future.

SUSTAINABLE WESTERN LUMBER

In the West, federal regulations, state forest practices acts and best management practices are among the most rigorous in the world. Forest products companies are also taking additional steps to assure that harvesting and forestry practices are being conducted sustainably.

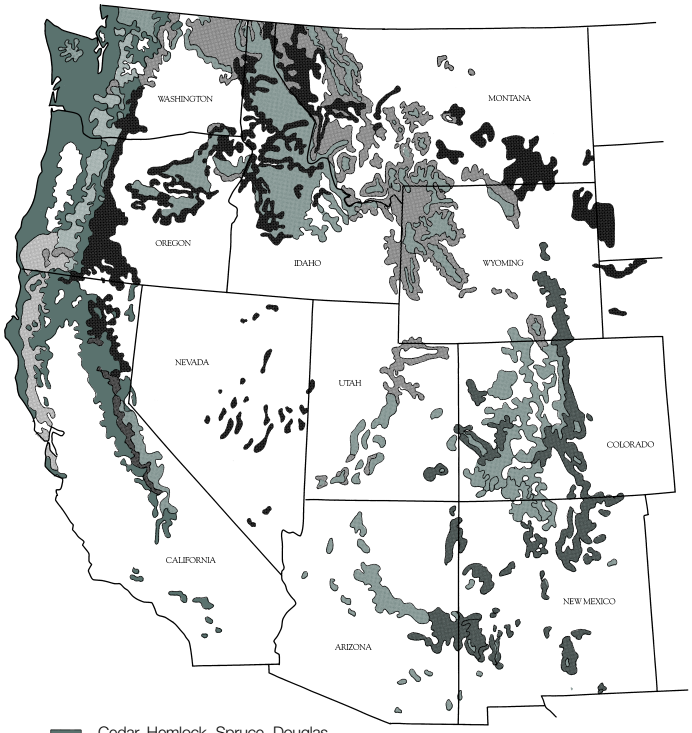
More than 10 million acres of timberland in the West have received independent, third-party certification though the Sustainable Forestry Initiative (SFI). Also, nearly 2.5 million acres of Western timberland are certified through the Forest Stewardship Council (FSC), with products from this timber marked to assure buyers that they come from forests that are managed to meet the social, economic and ecological needs of present and future generations.

These activities demonstrate the Western lumber industry's commitment to deliver environmentally friendly, sustainable forest products to the market now and in perpetuity.

SPECIES GROUPINGS

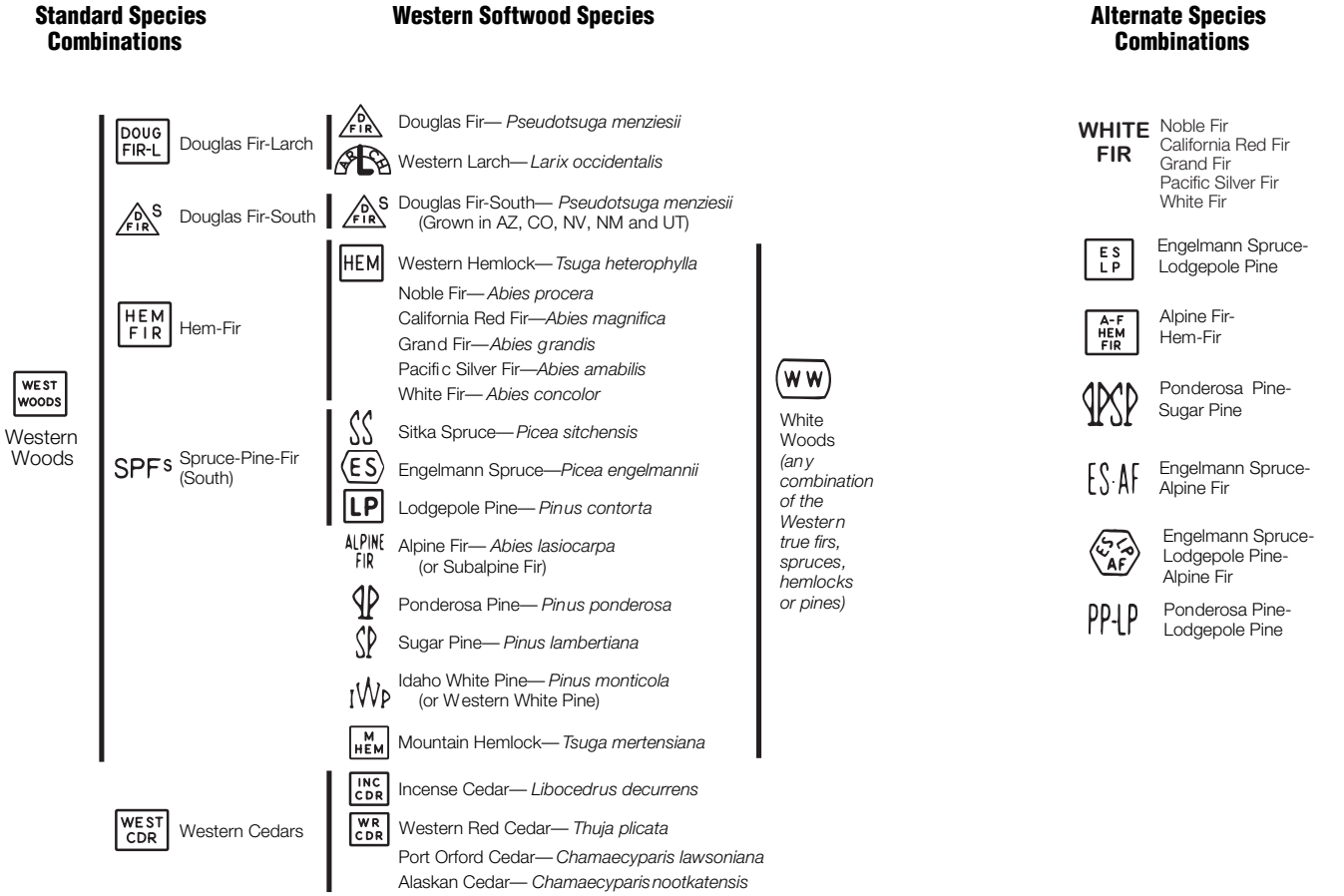
There are more than 15 commercially important Western softwood species. The lumber from several of the Western softwood species shares performance properties and is similar enough in appearance that many species are grouped together into "Marketing Categories." The species within these categories are often harvested, manufactured and sold interchangeably in the marketplace.

Western lumber may be bought, sold and specified as separate species or according to the species groups, or "Marketing Categories," shown on the map below and outlined on the following page.



Western Lumber Species and Grades

WESTERN LUMBER SPECIES MARKETING CATEGORIES



GRADE CATEGORIES

Western solid-sawn lumber is grouped into three broad categories: framing (or structural) lumber, which is graded for strength; appearance lumber, which is not graded for strength; and industrial (or factory) lumber, which is generally graded for specific end uses or for remanufacturing and recovery purposes.

Framing lumber includes the grades intended for structural applications in both conventional and pre-engineered framing systems. Western species structural lumber is manufactured primarily from second- and third-growth softwoods and graded, either visually or mechanically, on the basis of its strength; each species and grade has an assigned design value. General classifications include:

- Dimension lumber grades
- Special Dimension lumber grades
- Timber grades

Design values for Dimension lumber are published as BASE VALUES which must be adjusted for size as well as conditions of use. Refer to pages 5 to 17.

Appearance lumber includes a variety of non-structural grades intended for applications where strength is not the primary consideration. Appearance grade Western lumber is manufactured primarily from older (not “old growth”) and second-growth softwood trees. Many of the products in this category are often run-to-pattern for paneling and siding applications. General classifications include:

- High-quality Appearance grades
  (Selects, Finish and Special Western Red Cedar Grades)
- General purpose Board grades
  (Commons under WWPA Rules and
  Alternate Board Grades under WCLIB Rules)
- Radius-edged Patio Decking grades
  (Patio 1 and Patio 2)

Refer to pages 18 to 20.

Industrial lumber includes both structural and non-structural grades intended for specific applications. General classifications include:

- Structural grades
  (Mining Timbers, Scaffold Plank, Foundation lumber, Stress-Rated Boards)
- Factory and Shop grades
  (non-structural grades intended for cut up and remanufacturing)
- Non-structural grades
  (Gutter, Picket, Lath, Batten, Stepping)

Refer to pages 21 and 22.

Framing Lumber

WWPA GRADE STAMPS

Grading practices of WWPA mills are closely supervised by the Association's field team of Lumber Inspectors to assure uniformity and conformance to the *Western Lumber Grading Rules*. These rules establish standards for size and levels of quality in conformance with the American Softwood Lumber Standard PS 20, which can be viewed online at: **http://ts.nist.gov/docvps**

The *Grading Rules* provide the specifier with a dependable measure for determining the quality of lumber. Western lumber grades may be assigned visually or mechanically.

The building codes require that grade-marked lumber be used for structural applications. If practical, appearance grades such as Selects and Commons used for siding, paneling and soffits, may be specified end stamped. Most grade stamps, except those for rough lumber or heavy timbers, contain the five basic elements shown below:

a. WWPA Certification Mark: Certifies Association quality supervision. ® is a registered trademark.

b. Mill Identification: Firm name, brand or assigned mill number. A WWPA mill number list is available online at **www.wwpa.org/millno.htm**.

c. Grade Designation: Grade name, number or abbreviation.

d. Species Identification: Indicates species by individual species or species combination. Other species identification marks are shown in the species list on page 4.

e. Condition of Seasoning: Indicates condition of seasoning at the time of surfacing–

S-GRN - over 19% moisture content (unseasoned)
S-DRY, KD or KD HT - 19% maximum moisture content
MC15 or KD15 - 15% maximum moisture content

KD HT LUMBER GRADE STAMP

A KD HT mark, indicating the wood has been kiln dried (KD) and heat-treated (HT), is used to meet international regulations for wood pallet and packaging materials. The mark indicates lumber has been dried to a maximum moisture content of 19 percent or less, and was heat-treated to a lumber core temperature of 56ºC for a minimum of 30 minutes.

For structural framing applications, including Metal Plate Connected (MPC) wood trusses, the KD HT mark can be considered the same as surfaced dry (S-DRY) and KD.

LUMBER DESIGN VALUES

Design values for North American softwood structural lumber are determined in accordance with ASTM standards based on clear-wood tests and tests of graded lumber pieces. The applicable standards, based on results of tests conducted in cooperation with the USDA Forest Products Laboratory, are *ASTM Standards D 2555* and *D 245* for clear-wood, and *D 1990* for graded lumber specimens. Refer to Sections 100.00 to 180.00 of the *Western Lumber Grading Rules* for additional information.

Design values are published in the *Western Lumber Grading Rules*, incorporated into the *Supplement* to the *National Design Specification for Wood Construction® (NDS®)*, and are shown on the following pages of this publication; for NGR Dimension lumber in Table 1 (page 6) and for Timbers in Tables 4 and 5 (page 11). These design values are recognized by the model building codes. For any alternate species combinations (other than the standard species combinations) the species of lowest assigned design value governs the combination.

FRAMING LUMBER

The general classifications of framing lumber are Dimension, Special Dimension and Timbers. The lumber grades within these classifications are intended for structural applications in load-bearing situations.

The design values for Dimension lumber in Table 1 are published as BASE VALUES. BASE VALUES are constants that are applied to each grade in a particular species grouping. BASE VALUES *must be adjusted for size*, using the SIZE-ADJUSTMENT FACTORS in Table A. Design values in Table 3 are published in a SIZE-ADJUSTED FORMAT, and no size adjustment is necessary. All design values (in Tables 1-5) must be adjusted for conditions of use (Tables B-K) as appropriate. Refer to pages 7-9 for more information on using BASE VALUES. The checklists, after each classification of lumber, serve as reminders as to when and how to apply adjustments to the numbers in each table of design values.

Mechanical Properties - Lumber strength properties are assigned to five basic properties: fiber stress in bending (F_b), tension parallel to grain (F_t), horizontal shear (F_v), compression perpendicular to grain ($F_{c\perp}$) and compression parallel to grain (F_c). The modulus of elasticity (E or *MOE*) is a ratio of the amount a piece of lumber will deflect in proportion to an applied load. It is a measurement of stiffness and not a strength property. E_{min} is the modulus of elasticity for beam and column stability calculations. Refer to pages 12 and 13 for a description of these properties.

Western lumber design values are for use in all normal construction design. Higher or lower design values may be used to meet special structural requirements. Standard ASTM reductions have been made to the strength values to account for safety and duration of load. The *National Design Specification for Wood Construction® (NDS®)*, published by the American Forest & Paper Association, **www.awc.org**, 1111 19th Street, NW, Eighth Floor, Washington, DC 20036, sets forth design methods for structural applications.

Moisture Content and Heat Treating - Any of the abbreviations, S-GRN, HT, S-DRY, KD, KD HT, MC15, or KD15 may be found in a grade stamp to denote the moisture content (MC) of lumber at the time of surfacing. Designations are explained in the left column.

Unseasoned (S-GRN) lumber is manufactured oversized so that when it reaches 19% MC it will be approximately the same size as the dry size. Therefore, when unseasoned lumber is shipped, the same design values that are assigned and used for dry lumber also apply to S-GRN lumber.

Heat Treated (HT) lumber is lumber that has been placed in a closed chamber and heat added until the lumber achieves a minimum core temperature of 56ºC for a minimum of 30 minutes.

The word "DRY" indicates that a product was either kiln or air dried to a maximum moisture content of 19%. Kiln-dried (KD) lumber is lumber that has been seasoned in a chamber to a pre-determined moisture content by applying heat.

Kiln Dried Heat Treated (KD HT) lumber is lumber that has been placed in a closed chamber and heat added until the lumber achieves a minimum core temperature of 56ºC for a minimum of 30 minutes and which is dried to a maximum moisture content of 19% or less.

Framing lumber 2" and less in thickness may be seasoned to a moisture content of 19% or less, with the indication "S-DRY" or "KD" on the grade stamp. Surfaced framing lumber over 2" in thickness is typically shipped unseasoned and indicated "S-GRN" on the grade stamp. Regional market conditions dictate the availability of dry or unseasoned material.

Framing Lumber

BASE VALUES FOR WESTERN DIMENSION LUMBER[1]

Table **1**

Nominal Sizes: 2″ to 4″ thick by 2″ and wider[2]

Use with appropriate Adjustments, Tables A through G

Grades described in *Western Lumber Grading Rules*, Sections 40.00, 41.00, 42.00 and 62.00. Also Stress-Rated Boards, see Section 30.60

Species or Group	Grade	Extreme Fiber Stress in Bending	Tension Parallel to Grain	Horizontal Shear[3]	Compression		Modulus of Elasticity	
		Single Member F_b	F_t	F_v	Perpendicular $F_{c\perp}$	Parallel to Grain F_c	E	E_{min}
Douglas Fir-Larch	Select Structural	1500	1000	180	625	1700	1,900,000	690,000
	No. 1 & Btr.	1200	800	180	625	1550	1,800,000	660,000
	No. 1	1000	675	180	625	1500	1,700,000	620,000
Douglas Fir	No. 2	900	575	180	625	1350	1,600,000	580,000
Western Larch	No. 3	525	325	180	625	775	1,400,000	510,000
	Construction	1000	650	180	625	1650	1,500,000	550,000
	Standard	575	375	180	625	1400	1,400,000	510,000
	Utility	275	175	180	625	900	1,300,000	470,000
	Stud	700	450	180	625	850	1,400,000	510,000
Douglas Fir-South	Select Structural	1350	900	180	520	1600	1,400,000	510,000
	No. 1	925	600	180	520	1450	1,300,000	470,000
	No. 2	850	525	180	520	1350	1,200,000	440,000
Douglas Fir-South	No. 3	500	300	180	520	775	1,100,000	400,000
(grown in AZ, CO, NV, NM and UT)	Construction	975	600	180	520	1650	1,200,000	440,000
	Standard	550	350	180	520	1400	1,100,000	400,000
	Utility	250	150	180	520	900	1,000,000	370,000
	Stud	675	425	180	520	850	1,100,000	400,000
Hem-Fir	Select Structural	1400	925	150	405	1500	1,600,000	580,000
	No. 1 & Btr.	1100	725	150	405	1350	1,500,000	550,000
Western Hemlock	No. 1	975	625	150	405	1350	1,500,000	550,000
Noble Fir	No. 2	850	525	150	405	1300	1,300,000	470,000
California Red Fir	No. 3	500	300	150	405	725	1,200,000	440,000
Grand Fir	Construction	975	600	150	405	1550	1,300,000	470,000
Pacific Silver Fir	Standard	550	325	150	405	1300	1,200,000	440,000
White Fir	Utility	250	150	150	405	850	1,100,000	400,000
	Stud	675	400	150	405	800	1,200,000	440,000
Spruce-Pine-Fir (South)	Select Structural	1300	575	135	335	1200	1,300,000	470,000
	No. 1	875	400	135	335	1050	1,200,000	440,000
	No. 2	775	350	135	335	1000	1,100,000	400,000
Western Species:	No. 3	450	200	135	335	575	1,000,000	370,000
Engelmann Spruce	Construction	875	400	135	335	1200	1,000,000	370,000
Sitka Spruce	Standard	500	225	135	335	1000	900,000	330,000
White Spruce	Utility	225	100	135	335	675	900,000	330,000
Lodgepole Pine	Stud	600	275	135	335	625	1,000,000	370,000
Western Cedars	Select Structural	1000	600	155	425	1000	1,100,000	400,000
	No. 1	725	425	155	425	825	1,000,000	370,000
Western Red Cedar	No. 2	700	425	155	425	650	1,000,000	370,000
Incense Cedar	No. 3	400	250	155	425	375	900,000	330,000
Port Orford Cedar	Construction	800	475	155	425	850	900,000	330,000
Alaskan Cedar	Standard	450	275	155	425	650	800,000	290,000
	Utility	225	125	155	425	425	800,000	290,000
	Stud	550	325	155	425	400	900,000	330,000
Western Woods (and White Woods[4])	Select Structural	900	400	135	335	1050	1,200,000	440,000
	No. 1	675	300	135	335	950	1,100,000	400,000
Any of the species in the first four species groups above plus any or all of the following:	No. 2	675	300	135	335	900	1,000,000	370,000
	No. 3	375	175	135	335	525	900,000	330,000
	Construction	775	350	135	335	1100	1,000,000	370,000
	Standard	425	200	135	335	925	900,000	330,000
Idaho White Pine	Utility	200	100	135	335	600	800,000	290,000
Ponderosa Pine	Stud	525	225	135	335	575	900,000	330,000
Sugar Pine								
Alpine Fir								
Mountain Hemlock								

1 Design values in pounds per square inch.

2 Standard surfaced sizes are tabulated in Table 13.

3 All horizontal shear values are assigned in accordance with ASTM standards, which include a reduction to compensate for any degree of shake, check or split that might develop in a piece.

4 White Woods species group includes any species or combination of true firs, spruces, hemlocks or pines. Design values are the same as those assigned to Western Woods.

Framing Lumber

ADJUSTMENT FACTORS FOR BASE VALUES

SIZE FACTORS (C_F) — Table **A**

Apply to Dimension lumber BASE VALUES

Grades	Nominal Width (depth)	F_b 2″ & 3″ thick nominal	F_b 4″ thick nominal	F_t	F_c	Other Properties
SELECT STRUCTURAL, NO.1 & BTR., NO.1, NO.2 & NO.3	2″, 3″, & 4″	1.5	1.5	1.5	1.15	1.0
	5″	1.4	1.4	1.4	1.1	1.0
	6″	1.3	1.3	1.3	1.1	1.0
	8″	1.2	1.3	1.2	1.05	1.0
	10″	1.1	1.2	1.1	1.0	1.0
	12″	1.0	1.1	1.0	1.0	1.0
	14″ & wider	0.9	1.0	0.9	0.9	1.0
CONSTRUCTION & STANDARD	2″, 3″, & 4″	1.0	1.0	1.0	1.0	1.0
UTILITY	2″ & 3″	0.4	—	0.4	0.6	1.0
	4″	1.0	1.0	1.0	1.0	1.0
STUD	2″, 3″, & 4″	1.1	1.1	1.1	1.05	1.0
	5″ & 6″	1.0	1.0	1.0	1.0	1.0
	8″ & wider	Use No.3 grade Base Values and Size Factors				

REPETITIVE MEMBER FACTOR (C_r) — Table **B**

Apply to size-adjusted F_b

Where lumber is used repetitively, such as for joists, studs, rafters, and decking, the pieces side by side share the load and the strength of the entire assembly is enhanced. Therefore, where three or more members are adjacent or are not more than 24″ on center and are joined by floor, roof, or other load distributing elements, the F_b value can be increased 1.15 for repetitive member use.

Repetitive Member Use
$F_b \times 1.15$

DURATION OF LOAD ADJUSTMENT (C_D) — Table **C**

Apply to size-adjusted values

Wood has the property of carrying substantially greater maximum loads for short durations than for long durations of loading. Tabulated design values apply to normal load duration. (Factors do not apply to MOE or $F_{c\perp}$)

Load Duration	Factor
Permanent	0.9
Ten Years (Normal Load)	1.0
Two Months (Snow Load)	1.15
Seven Day	1.25
Ten Minutes (Wind and Earthquake Loads)	1.6
Impact	2.0

Confirm load requirements with local codes.

HORIZONTAL SHEAR DESIGN VALUES

Horizontal shear values published in Tables 1, 3, 4 and 5 are based upon the maximum degree of shake, check or split that might develop in a piece. Shear design values for lumber have been approved by the American Lumber Standard Committee, Inc.

Design provisions, including requirements for shear design of lumber, are published by the American Forest & Paper Association (AF&PA) in the *National Design Specification for Wood Construction® (NDS®)*, an ANSI national consensus standard.

DIMENSION LUMBER

Sizes/Design Values - Dimension lumber includes products that are nominal 2" to 4" in thickness by 2" and wider. It is available in the grades listed in Table 1 (page 6) with assigned design values published as BASE VALUES.

Dimension lumber BASE VALUES must be adjusted for size as well as conditions of use. Adjust the BASE VALUE (Table 1, page 6) according to the size factor (Table A, page 7) before adjusting for conditions of use.

Single member, size-adjusted fiber stress in bending (F_b) design value is for use where the strength of an individual piece, such as a small beam or post, is or may be responsible for carrying a specific design load. Repetitive member use is handled through an adjustment factor (Table B, page 7).

ADJUSTMENTS FOR DIMENSION LUMBER — Checklist **1**

The boxes in the checklist below indicate when and how to apply adjustments (Tables A–G) to the BASE VALUES in Table 1.

Base Values x *Adjustment Factors* x *Special Use Factors* = *Design Values*

Base Value	x	Size C_F	x	Repetitive Member C_r	x	Duration of Load C_D	x	Flat Use C_{fu}	x	Compression Perpendicular to Grain $C_{c\perp}$	x	Incising, Wet Use, Fire-Retardant[1], High-Temperature C_i C_M C_R C_t	=	Design Value
F_b		☐		☐		☐		☐				☐		F'_b Bending
F_t		☐				☐						☐		F'_t Tension
F_v						☐						☐		F'_v Shear
$F_{c\perp}$										☐		☐		$F'_{c\perp}$ Compression Perpendicular to Grain
F_c		☐				☐						☐		F'_c Compression Parallel to Grain
E, E_{min}												☐		E', E'_{min} Modulus of Elasticity
Table 1 page 6		Table A		Table B page 7		Table C		Table D		Table E page 9		Ch. 2 of NDS *National Design Specification for Wood Construction*		

[1] Adjustments for fire-retardant treatment shall be provided by the manufacturer providing the treatment.

Framing Lumber

Using BASE VALUES - Dimension lumber values are published as BASE VALUES in Table 1, page 6. BASE VALUES must first be adjusted for size (Table A, page 7) and then for conditions of use (Tables B-G, pages 7-9). The most common condition-of-use adjustments, Repetitive Member and Duration of Load, are shown with the SIZE ADJUSTMENT FACTORS on the preceding page. The adjustments for more specific conditions of use, such as Flat Use, Compression Perpendicular to Grain, Wet Use and Incising are presented on page 9. **Checklist 1, on page 7, provides a quick reference to all of the adjustments applicable to Dimension lumber BASE VALUES.** Once all appropriate adjustments are taken, the adjusted number becomes the design value for a specific piece in its application. Formulas for BASE VALUES are provided below.

BASE VALUE EQUATIONS Checklist **2**

Apply to Dimension lumber values in Table 1.

Base Value		Size Adjustment Factor		Routine Adjustment Factors		Conditions-of-Use Factors		Design Value
F_b	x	C_F	x	C_D x C_r	x	C_M x C_R x C_t x C_{fu} x C_i	=	F'_b
F_t	x	C_F	x	C_D	x	C_M x C_R x C_t x C_i	=	F'_t
F_v			x	C_D	x	C_M x C_R x C_t x C_i	=	F'_v
$F_{c\perp}$[1]					x	C_M x C_R x C_t x $C_{c\perp}$	=	$F'_{c\perp}$
F_c	x	C_F	x	C_D	x	C_M x C_R x C_t x C_i	=	F'_c
E					x	C_M x C_R x C_t x C_i	=	E'

[1] For $F_{c\perp}$ value of 0.02" deformation basis, see Table E.

Note:
- C_F = Size Factor
- C_r = Repetitive Member Factor
- C_D = Duration of Load
- C_{fu} = Flat Use Factor
- C_M = Wet Use Factor
- $C_{c\perp}$ = Adjustment for Compression Perpendicular to Grain
- C_i = Incising Factor
- C_R = Fire Retardant Factor, contact FRT manufacturer for adjustment factors
- C_t = High-Temperature Factor, refer to the National Design Specification

Grades/End-Uses - Dimension lumber (2" to 4" thick by 2" and wider) is available in the nine grades listed in Table 1, with BASE VALUES assigned to each grade in a species group. The grades are organized in the *National Grading Rule (NGR)* as Structural Light Framing, Light Framing, Stud and Structural Joists and Planks. These categories are related to size and strength as well as intended end uses.

2x2 through 4x4 - These sizes are available in the Structural Light Framing, Light Framing and Stud strength categories.

Structural Light Framing grades in 2x2 through 4x4 are intended to fit engineering applications where highest design values are needed in light framing sizes. A mix of SELECT STRUCTURAL and NO. 1 may be gradestamped as NO. 1 & BTR in Douglas Fir, Douglas Fir-Larch or Hem-Fir. Typical uses include trusses, concrete forms and engineered applications. (Numbers in parentheses below are references to paragraph numbers in the *Western Lumber Grading Rules*.)

Structural Light Framing (SLF) grades are:

SELECT STRUCTURAL	(42.10)
NO. 1	(42.11)
NO. 2	(42.12)
NO. 3	(42.13)

Light Framing grades in 2x2 through 4x4 are intended for use where high strength values are not required, such as for wall framing, plates, sills, cripples and blocking.

Light Framing (LF) grades are:

CONSTRUCTION	(40.11)
STANDARD	(40.12)
UTILITY	(40.13)

2x2 through 4x18 - Products within this category can be graded as STUD grade. It is an optional all-purpose grade. (Structural end-glued products are limited to 2x2 through 2x6, 12' and shorter.) Characteristics affecting strength and stiffness values are limited so that **STUD** grade is suitable for stud uses, including load-bearing walls.

STUD	(41.13)

2x5 through 4x18 - These sizes, categorized in the *NGR* as Structural Joists and Planks, are intended to fit engineering applications for lumber 5" and wider, such as floor joists, rafters, headers, small beams, trusses and general framing uses. A mix of SELECT STRUCTURAL and NO. 1 may be gradestamped NO. 1 & BTR J&P in Douglas Fir, Douglas Fir-Larch or Hem-Fir.

Structural Joists and Planks (SJ&P) grades are:

SELECT STRUCTURAL	(62.10)
NO. 1	(62.11)
NO. 2	(62.12)
NO. 3	(62.13)

STRUCTURAL-GLUED LUMBER PRODUCTS

U.S. model building codes have approved the same design values for both solid-sawn Dimension lumber and Structural-glued lumber products.

Currently, WWPA certifies the manufacture of structural-glued Dimension lumber in various species and grades under the following classifications: Light Framing and Studs, Structural Light Framing, Decking, Stress-rated Boards, Structural Joists and Planks, Posts and Timbers, and Beams and Stringers.

A WWPA grade stamp is issued and used only if the material complies with all applicable sections of WWPA's *Glued Products Procedures for Certification and Quality Control* or *Certified Glued Lumber Procedures for Mill Certification and Quality Control*. HRA designates the use of heat-resistant adhesives in structural-glued products which comply with building code requirements for fire-resistance-rated assemblies. NON-HRA designates the use of adhesives which conform to building code requirements where fire-resistance-rated assemblies are not required. Order WWPA's *Structural-Glued Lumber* (TG-9) publication for additional information.

Typical grade stamp showing HRA designation

Typical NON-HRA grade stamp

Framing Lumber

ADDITIONAL ADJUSTMENT FACTORS FOR DIMENSION LUMBER

FLAT USE FACTORS (C_{fu}) — Table **D**

Apply to size-adjusted F_b

Nominal Width	Nominal Thickness 2″ & 3″	4″
2″ & 3″	1.00	—
4″	1.10	1.00
5″	1.10	1.05
6″	1.15	1.05
8″	1.15	1.05
10″ & wider	1.20	1.10

ADJUSTMENTS FOR COMPRESSION PERPENDICULAR TO GRAIN ($C_{c\perp}$) — Table **E**

For deformation basis of 0.02″. Apply to $F_{c\perp}$ values

Design values for compression perpendicular to grain ($F_{c\perp}$) are established in accordance with the procedures set forth in ASTM Standards D 2555 and D 245. ASTM procedures consider deformation under bearing loads as a serviceability limit state comparable to bending deflection because bearing loads rarely cause structural failures. Therefore, ASTM procedures for determining compression perpendicular to grain values are based on a deformation basis of 0.04″ and are considered adequate for most classes of structures. Where more stringent measures need to be taken in design, the following formula permits the designer to adjust design values to a more conservative deformation basis of 0.02″: $F_{c\perp\,0.02} = 0.73\ F_{\perp}$

Example: Douglas Fir-Larch: $F_{\perp} = 625$ psi

$F_{c\perp\,0.02} = 0.73\ (625) = 456$ psi

WET USE FACTORS (C_M) — Table **F**

Apply to size-adjusted values

The design values shown in Tables 1, 2 and 3 are for routine construction applications where the moisture content of the wood does not exceed 19% in use. When use conditions are such that the moisture content of Dimension lumber will exceed 19% in use, the Wet Use Adjustment Factors below are recommended.

Property	Adjustment Factor
F_b	0.85[1]
F_t	1.0
F_c	0.8[2]
F_v	0.97
$F_{c\perp}$	0.67
E, E_{min}	0.9

[1] Wet Use Factor 1.0 for size-adjusted F_b not exceeding 1150 psi.
[2] Wet Use Factor 1.0 for size-adjusted F_c not exceeding 750 psi.

INCISING FACTORS (C_i) — Table **G**

Apply to size-adjusted values

Tabulated design values shall be multiplied by the following incising factor (C_i), when Dimension lumber is incised parallel to grain to a maximum depth of 0.4", a maximum length of ⅜", and density of incisions of 1,000/ft². Incising factors shall be determined by test or by calculation using reduced section properties for incising patterns exceeding these limits.

Property	Adjustment Factor
E, E_{min}	0.95
F_b, F_t, F_c, F_v	0.80
$F_{c\perp}$	1.00

SPECIAL DIMENSION LUMBER

There are two categories of Special Dimension lumber grades. Design values are shown in Tables 2 and 3 for these categories:

a. Structural Decking - 2x4 through 4x12;
b. Machine Stress-Rated lumber (MSR) - nominal 2" and less in thickness, 2" and wider.

STRUCTURAL DECKING

Grades/End Uses - Standard decking patterns, in nominal 2" single T&G and 3" and 4" double T&G, are available in vee or eased joints to meet most architectural design requirements. For diagrams of available patterns and sizes, order WWPA's publication *Standard Patterns* (G-16). Two grades are available. **Published design values need to be adjusted for depth effect**. Refer to Tables 2 and H below. Decking spans are provided in Table 10, page 15.

STRUCTURAL DECKING DESIGN VALUES[1] — Table **2**

Sizes: 2″ to 4″ thick, 4″ to 12″ wide
Use with appropriate Adjustments in Tables C, F, G, H
For flatwise use only

Species	Decking Grade	DRY or MC15 F_b Single Member	F_b Repetitive Member	Compression Perpendicular $F_{c\perp}$	Modulus of Elasticity E	E_{min}
Douglas Fir-Larch	Selected	1750	2000	625	1,800,000	660,000
	Commercial	1450	1650	625	1,700,000	620,000
Douglas Fir-South	Selected	1650	1900	520	1,400,000	510,000
	Commercial	1400	1600	520	1,300,000	470,000
Hem-Fir	Selected	1400	1600	405	1,500,000	550,000
	Commercial	1150	1350	405	1,400,000	510,000
SPF[S]	Selected	1150	1350	335	1,400,000	510,000
	Commercial	950	1100	335	1,200,000	440,000
Western Cedars	Selected	1250	1450	425	1,100,000	400,000
	Commercial	1050	1200	425	1,000,000	370,000
Western Woods	Selected	1150	1300	335	1,200,000	440,000
	Commercial	950	1100	335	1,100,000	400,000

[1] Design values in pounds per square inch. See Table 1 (page 6) for horizontal shear (F_v) values.

ADJUSTMENT FACTORS FOR DEPTH EFFECT (C_F) — Table **H**

For all widths of Structural Decking

Decking bending design values may be adjusted for thickness as shown below because the bending values shown in Table 2 are based on a 4″ thick member loaded flatwise.

Nominal Thickness 2″	3″	4″
1.10	1.04	1.00

ADJUSTMENTS FOR STRUCTURAL DECKING — Checklist **3**

☐ Duration of Load (C_D)	Table C, page 7
☐ Wet Use Factor (C_M)	Table F, page 9
☐ Incising Factor (C_i)	Table G, page 9
☐ Depth Effect (C_F)	Table H, page 9

Framing Lumber

MSR LUMBER

Machine Stress-Rated lumber (MSR) is Dimension lumber that has been evaluated by mechanical stress-rating equipment. The stress-rating equipment measures the stiffness of the material and sorts it into various modulus of elasticity (*E*) classes.

Research has shown that a direct relationship exists between the bending stiffness of a piece of lumber, its bending strength or modulus of rupture (MOR), and its ultimate tensile strength (UTS).

Since the only way to determine strength values is to actually break the piece, the next best alternative is to measure the stiffness, compute the modulus of elasticity, and then predict the strength values.

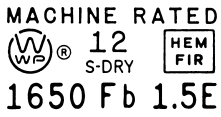
Following this "*E*" sorting, each piece must also meet certain visual requirements and daily quality control test procedures for both F_b and *E*.

Voluntary procedures - Because there is a direct relationship between specific gravity values and MSR lumber grades (with higher-strength grades having higher specific gravity values), some MSR lumber producers provide voluntary daily quality control for specific gravity (*SG*) and/or tension (F_t) in addition to the mandatory F_b and *E* testing. When these additional levels of quality control are provided, the producer may include the appropriate F_t, *SG* and specific gravity-related compression perpendicular to grain value ($F_{c\perp}$), and horizontal shear (F_v) values on the grade stamp in addition to F_b and *E*. MSR producers providing one or more of these additional levels of quality control may choose to limit the number of grades which are subject to F_t and *SG* testing.

End Uses - One of the prime uses for Machine Stress-Rated lumber is trusses. However, this product is also used as floor and ceiling joists, as rafters and for other structural purposes where assured strength capabilities are primary product considerations.

Code Acceptability - MSR lumber produced under an approved grading agency's certification and quality control procedures is accepted by regulatory agencies and all major building codes.

Refer to page 17 for information on specifying MSR lumber. Order WWPA's *Machine Stress-Rated Lumber* (TG-4) publication for additional information on MSR products and quality control procedures.



Typical MSR Stamp

MSR Stamp with Tension and Specific Gravity Quality Control

When MSR lumber is visually graded for optional wane limitations as described in WWPA's *Western Lumber Grade Rules*, the grade stamp includes the mark "1W".

DESIGN VALUES

When designing with MSR lumber, the appropriate adjustments in Tables B-G must be applied to the numbers in Table 3.

***F_b*:** For any given value of F_b the average modulus of elasticity (*E*), may vary depending on species, timber source and other variables. The *E* value included in the F_b-*E* grade designations in Table 3 are those usually associated with each F_b level. Grade stamps may show higher or lower *E* values (in increments of 100,000 psi) if machine rating indicates the assignment is appropriate. When an *E* value varies from the designated F_b level in the table, the tabulated F_b, F_t and F_c values associated with the designated F_b value are applicable.

DESIGN VALUES[1] Table **3**
MACHINE STRESS-RATED LUMBER

2″ and less in thickness, 2″ and wider
Use with appropriate Adjustments in Tables B through G

Grade Designation	F_b Single	*E*	E_{min}	F_t	F_c
2850 F_b-2.3*E*	2850	2,300,000	1,170,000	2300	2150
2700 F_b-2.2*E*	2700	2,200,000	1,120,000	2150	2100
2550 F_b-2.1*E*	2550	2,100,000	1,070,000	2050	2025
2400 F_b-2.0*E*	2400	2,000,000	1,020,000	1925	1975
2250 F_b-1.9*E*	2250	1,900,000	970,000	1750	1925
2100 F_b-1.8*E*	2100	1,800,000	910,000	1575	1875
1950 F_b-1.7*E*	1950	1,700,000	860,000	1375	1800
1800 F_b-1.6*E*	1800	1,600,000	810,000	1175	1750
1650 F_b-1.5*E*	1650	1,500,000	760,000	1020	1700
1500 F_b-1.4*E*	1500	1,400,000	710,000	900	1650
1450 F_b-1.3*E*	1450	1,300,000	660,000	800	1625
1350 F_b-1.3*E*	1350	1,300,000	660,000	750	1600
1200 F_b-1.2*E*	1200	1,200,000	610,000	600	1400
900 F_b-1.0*E*	900	1,000,000	510,000	350	1050

[1] Design values in pounds per square inch

***$F_{c\perp}$* and *F_v*:** Design values for compression perpendicular to grain ($F_{c\perp}$), and horizontal shear (F_v), are the same as assigned to visually graded lumber of the appropriate species. These average $F_{c\perp}$ and F_v values for Western lumber are provided in Table 1, page 6.

DERIVING COMPRESSION PERPENDICULAR TO GRAIN VALUE (Fc>)

When a grade of MSR lumber is qualified by testing and daily quality control for specific gravity (SG), the allowable $F_{c\perp}$ value may be calculated by the following formula:

$$F_{c\perp} = (2252.4 \times SG) - 480$$

$F_{c\perp}$ values, determined by the above equation, are based on a 0.04" deformation limit and are for the design of most structures. Values based on 0.02" deformation can be obtained with the following formulas:

$$F_{c\perp 0.02} = 14.6 + (0.71 \times F_{c\perp})$$
$$F_{c\perp 0.02} = (1605.5 \times SG) - 327.5$$

DERIVING HORIZONTAL SHEAR VALUE (F_v)

When a grade of MSR lumber is qualified by testing and daily quality control for specific gravity (SG), the allowable F_v value may be calculated using the following formula:

$$F_v = 40 + (266 \times SG)$$

ADJUSTMENTS FOR MSR LUMBER Checklist **4**

☐	Repetitive Member Use Factor (C_r)	Table B, page 7
☐	Duration of Load (C_D)	Table C, page 7
☐	Flat Use Factor (C_{fu})	Table D, page 9
☐	Compression Perpendicular ($C_{c\perp}$)	Table E, page 9
☐	Wet Use Factor (C_M)	Table F, page 9
☐	Incising Factor (C_i)	Table G, page 9

Framing Lumber

BEAMS & STRINGERS DESIGN VALUES[1]

Table **4**

5″ and thicker, width more than 2″ greater than thickness[2]

Grades described in Sections 53.00 and 70.00 of *Western Lumber Grading Rules*

Species or Group	Grade	Extreme Fiber Stress in Bending	Tension Parallel to Grain	Horizontal Shear[3]	Compression		Modulus of Elasticity	
		Single Member F_b	F_t	F_v	Perpendicular $F_{c\perp}$	Parallel to Grain F_c	E	E_{min}
Douglas Fir-Larch	Dense Select Structural	1900	1100	170	730	1300	1,700,000	620,000
	Dense No. 1	1550	775	170	730	1100	1,700,000	620,000
	Dense No. 2	1000	500	170	730	700	1,400,000	510,000
	Select Structural	1600	950	170	625	1100	1,600,000	580,000
	No. 1	1350	675	170	625	925	1,600,000	580,000
	No. 2	875	425	170	625	600	1,300,000	470,000
Douglas Fir-South	Select Structural	1550	900	165	520	1000	1,200,000	440,000
	No. 1	1300	625	165	520	850	1,200,000	440,000
	No. 2	825	425	165	520	550	1,000,000	370,000
Hem-Fir	Select Structural	1300	750	140	405	925	1,300,000	470,000
	No. 1	1050	525	140	405	750	1,300,000	470,000
	No. 2	675	350	140	405	500	1,100,000	400,000
Mountain Hemlock	Select Structural	1350	775	170	570	875	1,100,000	400,000
	No. 1	1100	550	170	570	725	1,100,000	400,000
	No. 2	725	375	170	570	475	900,000	330,000
Sitka Spruce	Select Structural	1200	675	140	435	825	1,300,000	470,000
	No. 1	1000	500	140	435	675	1,300,000	470,000
	No. 2	650	325	140	435	450	1,100,000	400,000
Spruce-Pine-Fir (South)	Select Structural	1050	625	125	335	675	1,200,000	440,000
	No. 1	900	450	125	335	550	1,200,000	440,000
	No. 2	575	300	125	335	375	1,000,000	370,000
Western Cedars	Select Structural	1150	675	140	425	875	1,000,000	370,000
	No. 1	975	475	140	425	725	1,000,000	370,000
	No. 2	625	325	140	425	475	800,000	290,000
Western Hemlock	Select Structural	1400	825	170	410	1000	1,400,000	510,000
	No. 1	1150	575	170	410	850	1,400,000	510,000
	No. 2	750	375	170	410	550	1,100,000	400,000
Western Woods (and White Woods)	Select Structural	1050	625	125	345	750	1,100,000	400,000
	No. 1	900	450	125	345	625	1,100,000	400,000
	No. 2	575	300	125	345	425	900,000	330,000

1 Design Values in pounds per square inch. See Sections 100.00 through 180.00 in the *Western Lumber Grading Rules* for additional information on these values.

2 When the depth of a sawn lumber member exceeds 12 inches, the design value for extreme fiber stress in bending (F_b) shall be multiplied by the size factor in Table J.

3 All horizontal shear values are assigned in accordance with ASTM standards, which include a reduction to compensate for any degree of shake, check or split that might develop in a piece.

POSTS & TIMBERS DESIGN VALUES[1]

Table **5**

5″ × 5″ and larger, width not more than 2″ greater than thickness[2]

Grades described in Sections 53.00 and 80.00 of *Western Lumber Grading Rules*

Species or Group	Grade	Extreme Fiber Stress in Bending	Tension Parallel to Grain	Horizontal Shear[3]	Compression		Modulus of Elasticity	
		Single Member F_b	F_t	F_v	Perpendicular $F_{c\perp}$	Parallel to Grain F_c	E	E_{min}
Douglas Fir-Larch	Dense Select Structural	1750	1150	170	730	1350	1,700,000	620,000
	Dense No. 1	1400	950	170	730	1200	1,700,000	620,000
	Dense No. 2	850	550	170	730	825	1,400,000	510,000
	Select Structural	1500	1000	170	625	1150	1,600,000	580,000
	No. 1	1200	825	170	625	1000	1,600,000	580,000
	No. 2	750	475	170	625	700	1,300,000	470,000
Douglas Fir-South	Select Structural	1450	950	165	520	1050	1,200,000	440,000
	No. 1	1150	775	165	520	925	1,200,000	440,000
	No. 2	675	450	165	520	650	1,000,000	370,000
Hem-Fir	Select Structural	1200	800	140	405	975	1,300,000	470,000
	No. 1	975	650	140	405	850	1,300,000	470,000
	No. 2	575	375	140	405	575	1,100,000	400,000
Mountain Hemlock	Select Structural	1250	825	170	570	925	1,100,000	400,000
	No. 1	1000	675	170	570	800	1,100,000	400,000
	No. 2	625	400	170	570	550	900,000	330,000
Sitka Spruce	Select Structural	1150	750	140	435	875	1,300,000	470,000
	No. 1	925	600	140	435	750	1,300,000	470,000
	No. 2	550	350	140	435	525	1,100,000	400,000
Spruce-Pine-Fir (South)	Select Structural	1000	675	125	335	700	1,200,000	440,000
	No. 1	875	550	125	335	625	1,200,000	440,000
	No. 2	475	325	125	335	425	1,000,000	370,000
Western Cedars	Select Structural	1100	725	140	425	925	1,000,000	370,000
	No. 1	875	600	140	425	800	1,000,000	370,000
	No. 2	550	350	140	425	550	800,000	290,000
Western Hemlock	Select Structural	1300	875	170	410	1100	1,400,000	510,000
	No. 1	1050	700	170	410	950	1,400,000	510,000
	No. 2	650	425	170	410	650	1,100,000	400,000
Western Woods (and White Woods)	Select Structural	1000	675	125	345	800	1,100,000	400,000
	No. 1	800	525	125	345	700	1,100,000	400,000
	No. 2	475	325	125	345	475	900,000	330,000

1 Design Values in pounds per square inch. See Sections 100.00 through 180.00 in the *Western Lumber Grading Rules* for additional information on these values.

2 When the depth of a sawn lumber member exceeds 12 inches, the design value for extreme fiber stress in bending (F_b) shall be multiplied by the size factor in Table J.

3 All horizontal shear values are assigned in accordance with ASTM standards, which include a reduction to compensate for any degree of shake, check or split that might develop in a piece.

Framing Lumber

TIMBERS

Grades/End Uses - "Timbers" is both a general classification for the larger sizes of structural framing lumber and the name of a specific grade and size. There are two basic grade groups within this Timbers classification:

- **Beams and Stringers** - 5" and thicker, width more than 2" greater than thickness (6x10, 8x12, etc.);
- **Posts and Timbers** - 5x5 and larger, width not more than 2" greater than thickness (6x6, 6x8, etc.)

Design values assigned to each grade and species group are shown in Tables 4 and 5, page 11. End uses include heavy framing applications in both conventional and pre-engineered systems. This classification of grades requires its own Wet Use, Size/Depth Effect and Flat Use adjustments (see below).

ADJUSTMENT FACTORS FOR TIMBERS

WET USE FACTOR (C_M) — Table I

Apply to Beams & Stringers/Posts & Timbers
5″ and thicker lumber

When lumber 5″ and thicker is designed for exposed uses where the moisture content will exceed 19% in use for an extended period of time, the design values shown in Tables 4 and 5 should be multiplied by the following adjustment factors:

F_b	F_t	F_v	$F_{c\perp}$	F_c	E
1.00	1.00	1.00	0.67	0.91	1.00

SIZE/DEPTH EFFECT ADJUSTMENT (C_F) — Table J

Apply to Beams & Stringers/Posts & Timbers
5″ and thicker lumber

When the depth of a sawn lumber member exceeds 12 inches, the design value for extreme fiber stress in bending (F_b) shall be multiplied by the size factor C_F, as determined by this formula:

$$C_F = \left(\frac{12}{d}\right)^{1/9}$$

Note: The following adjustment factors are derived from the formula above.

Nominal Depth	Net Surfaced Depth (d)	Depth Adjustment Factor (C_F)
14	13.5	0.987
16	15.5	0.972
18	17.5	0.959
20	19.5	0.947
22	21.5	0.937
24	23.5	0.928
26	25.5	0.920
28	27.5	0.912
30	29.5	0.905

In structural designs for loads applied on the wide face, the fiber stress in bending and Modulus of Elasticity (MOE) values in Table 4 should be multiplied by the factors shown in the following table.

FLAT USE FACTOR (C_{fu}) — Table K

Apply to Beams & Stringers subjected to loads applied on the wide face[1]

Grade	F_b	E	Other Properties
Select Structural	0.86	1.00	1.00
No. 1	0.74	0.90	1.00
No. 2	1.00	1.00	1.00

[1] Posts and Timbers graded to Section 70.10, 70.11 and 70.12 of the *Western Lumber Grading Rules* may use the design values in Table 4 without the above flat-use adjustment factors.

ADJUSTMENTS FOR BEAMS & STRINGERS/ POSTS & TIMBERS — Checklist 5

☐ Repetitive Member Use Factor (C_r)	Table B, page 7
☐ Duration of Load (C_D)	Table C, page 7
☐ Compression Perpendicular ($C_{C\perp}$)	Table E, page 9
☐ Wet Use Adjustment (C_M)	Table I, page 12
☐ Depth Effect	Table J, page 12
☐ Flat Use (C_{fu})	Table K, page 12

MECHANICAL PROPERTIES ILLUSTRATED

Extreme Fiber Stress in Bending - F_b (Fig. 1) When loads are applied, structural members bend, producing tension in the fibers along the faces farthest from the applied load and compression in the fibers along the face nearest to the applied load. These induced stresses in the fibers are designated as "extreme fiber stress in bending" (F_b).

Single Member F_b design values are used in design where the strength of an individual piece, such as a beam, may be solely responsible for carrying a specific design load.

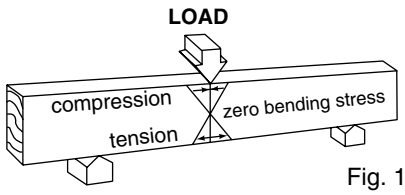


Fig. 1

Repetitive Member F_b design values are used in design when three or more load sharing members, such as joists, rafters, or studs, are spaced no more than 24" apart and are joined by flooring, sheathing or other load-distributing elements. Repetitive members are also used where pieces are adjacent, such as decking.

Fiber Stress in Tension - F_t (Fig. 2) Tensile stresses are similar to compression parallel to grain in that they act across the full cross section and tend to stretch the piece. Length does not affect tensile stresses.


Fig. 2

Framing Lumber

Horizontal Shear - F_v
(Fig. 3) Horizontal shear stresses tend to slide fibers over each other horizontally. Most predominate in short, heavily loaded deep beams. Increasing beam cross section decreases shear stresses.

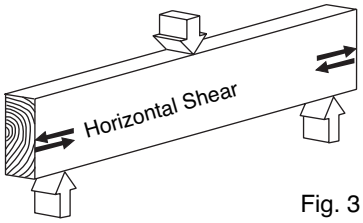


Fig. 3

Compression Perpendicular to Grain - $F_{c\perp}$ (Fig. 4)
Where a joist, beam or similar piece of lumber bears on supports, the load tends to compress the fibers. It is necessary that the bearing area be sufficient to prevent excessive side-grain crushing.

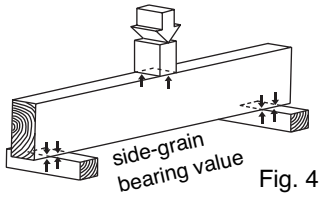


Fig. 4

Compression Parallel to Grain - F_c (Fig. 5)
In many parts of a structure, stress grades are used where the loads are supported on the ends of the pieces. Such uses are as studs, posts, columns and struts. The internal stress induced by this kind of loading is the same across the whole cross section and the fibers are uniformly stressed parallel to and along the full length of the piece.


Fig. 5

Modulus of Elasticity - E (Fig. 6)
The modulus of elasticity is a ratio of the amount a material will deflect in proportion to an applied load.

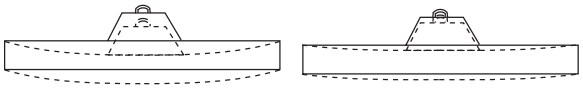


Fig. 6

Note: Modulus of Elasticity - E_{min}
E_{min} is the modulus of elasticity for beam and column stability calculations.

STANDARD SIZES - FRAMING LUMBER Table **6**
Nominal & Dressed (Based on *Western Lumber Grading Rules*)

Product	Description	Nominal Size Thickness inch	Nominal Size Width inch	Dressed (surfaced) Size Thicknesses & Widths — Surfaced Dry inch	Surfaced Dry mm	Surfaced Unseasoned inch	Surfaced Unseasoned mm	Length feet
DIMENSION	S4S	2	2	1½	38	1⁹⁄₁₆	40	6′ (183 cm) and longer, generally shipped in multiples of 2′ (61 cm)
		3	3	2½	64	2⁹⁄₁₆	65	
		4	4	3½	89	3⁹⁄₁₆	90	
			5	4½	114	4⅝	117	
			6	5½	140	5⅝	143	
			8	7¼	184	7½	191	
			10	9¼	235	9½	241	
			12	11¼	289	11½	292	
			over 12	¾ off nominal	19 off nominal	½ off nominal	13 off nominal	

Product	Description	Nominal Size Thickness inch	Nominal Size Width inch	Dressed (surfaced) Size Thicknesses & Widths — Thickness Unseasoned / Width Unseasoned	Length feet
TIMBERS	Rough or S4S (shipped unseasoned)	5 and larger	5 and larger	½″ (13mm) off nominal (S4S). See 3.20 of WWPA Grading Rules for Rough.	6′ (183 cm) and longer, generally shipped in multiples of 2′ (61 cm)

Product	Description	Nominal Size Thickness	Nominal Size Width	Dressed (surfaced) Size Thicknesses & Widths — Thickness Dry inch	Thickness Dry mm	Width Dry inch	Width Dry mm	Length feet
DECKING	2″ (Single T&G)	2	5	1½	38	4	102	6′ (183 cm) and longer, generally shipped in multiples of 2′ (61 cm)
			6			5	127	
			8			6¾	172	
			10			8¾	222	
			12			10¾	273	
	3″ and 4″ (Double T&G)	3	6	2½	64	5¼	133	
		4		3½	89			

Abbreviations: T&G—Tongued and grooved Rough—Unsurfaced S4S—Surfaced four sides
Note on Metrics: Metric equivalents are provided for surfaced (actual) sizes.

Framing Lumber

FLOOR JOIST SPANS[1]

Table **7**

40# LIVE LOAD 10# DEAD LOAD
L/360

Design Criteria: *Strength* - 10 lbs. per sq. ft. dead load plus 40 lbs. per sq. ft. live load.
Deflection - Limited in span in inches divided by 360 for live load only.

Species or Group	Grade	Span (feet and inches)															
		2 x 8				2 x 10				2 x 12				2 x 14			
		spacing on center															
		12"	16"	19.2"	24"	12"	16"	19.2"	24"	12"	16"	19.2"	24"	12"	16"	19.2"	24"
Douglas Fir-Larch	Sel. Struc.	15-0	13-7	12-10	11-11	19-1	17-4	16-4	15-2	23-3	21-1	19-10	18-5	27-4	24-10	23-5	21-4
	1 & Btr.	14-8	13-4	12-7	11-8	18-9	17-0	16-0	14-9	22-10	20-9	19-1	17-1	26-10	23-4	21-4	19-1
	No. 1	14-5	13-1	12-4	11-0	18-5	16-5	15-0	13-5	22-0	19-1	17-5	15-7	24-7	21-4	19-5	17-5
	No. 2	14-2	12-9	11-8	10-5	18-0	15-7	14-3	12-9	20-11	18-1	16-6	14-9	23-4	20-3	18-5	16-6
	No. 3	11-3	9-9	8-11	8-0	13-9	11-11	10-11	9-9	16-0	13-10	12-7	11-3	17-10	15-5	14-1	12-7
Douglas Fir-South	Sel. Struc.	13-6	12-3	11-7	10-9	17-3	15-8	14-9	13-8	21-0	19-1	17-11	16-8	24-8	22-5	21-1	19-7
	No. 1	13-2	12-0	11-3	10-6	16-10	15-3	14-5	12-11	20-6	18-4	16-9	15-0	23-8	20-6	18-9	16-9
	No. 2	12-10	11-8	11-0	10-2	16-5	14-11	13-10	12-5	19-11	17-7	16-1	14-4	22-8	19-8	17-11	16-1
	No. 3	11-0	9-6	8-8	7-9	13-5	11-8	10-7	9-6	15-7	13-6	12-4	11-0	17-5	15-1	13-9	12-4
Hem-Fir	Sel. Struc.	14-2	12-10	12-1	11-3	18-0	16-5	15-5	14-4	21-11	19-11	18-9	17-5	25-10	23-6	22-1	20-6
	1 & Btr.	13-10	12-7	11-10	11-0	17-8	16-0	15-1	14-0	21-6	19-6	18-3	16-4	25-3	22-4	20-5	18-3
	No. 1	13-10	12-7	11-10	10-10	17-8	16-0	14-10	13-3	21-6	18-10	17-2	15-5	24-4	21-1	19-3	17-2
	No. 2	13-2	12-0	11-3	10-2	16-10	15-2	13-10	12-5	20-4	17-7	16-1	14-4	22-8	19-8	17-11	16-1
	No. 3	11-0	9-6	8-8	7-9	13-5	11-8	10-7	9-6	15-7	13-6	12-4	11-0	17-5	15-1	13-9	12-4
Spruce-Pine-Fir (South)	Sel. Struc.	13-2	12-0	11-3	10-6	16-10	15-3	14-5	13-4	20-6	18-7	17-6	16-3	24-1	21-11	20-7	19-2
	No. 1	12-10	11-8	11-0	10-2	16-5	14-11	14-0	12-7	19-11	17-10	16-3	14-7	23-0	19-11	18-2	16-3
	No. 2	12-6	11-4	10-8	9-8	15-11	14-6	13-3	11-10	19-4	16-10	15-4	13-9	21-8	18-9	17-2	15-4
	No. 3	10-5	9-0	8-3	7-5	12-9	11-0	10-1	9-0	14-9	12-10	11-8	10-5	16-6	14-4	13-1	11-8
Western Woods	Sel. Struc.	12-10	11-8	11-0	10-2	16-5	14-11	14-0	12-9	19-11	18-1	16-6	14-9	23-4	20-3	18-5	16-6
	No. 1	12-6	11-1	10-1	9-0	15-7	13-6	12-4	11-0	18-1	15-8	14-4	12-10	20-3	17-6	16-0	14-4
	No. 2	12-1	11-0	10-1	9-0	15-5	13-6	12-4	11-0	18-1	15-8	14-4	12-10	20-3	17-6	16-0	14-4
	No. 3	9-6	8-3	7-6	6-9	11-8	10-1	9-2	8-3	13-6	11-8	10-8	9-6	15-1	13-1	11-11	10-8

FLOOR JOIST SPANS[1]

Table **8**

30# LIVE LOAD 10# DEAD LOAD
L/360

Design Criteria: *Strength* - 10 lbs. per sq. ft. dead load plus 30 lbs. per sq. ft. live load.
Deflection - Limited in span in inches divided by 360 for live load only.

Species or Group	Grade	Span (feet and inches)															
		2 x 6				2 x 8				2 x 10				2 x 12			
		spacing on center															
		12"	16"	19.2"	24"	12"	16"	19.2"	24"	12"	16"	19.2"	24"	12"	16"	19.2"	24"
Douglas Fir-Larch	Sel. Struc.	12-6	11-4	10-8	9-11	16-6	15-0	14-1	13-1	21-0	19-1	18-0	16-8	25-7	23-3	21-10	20-3
	1 & Btr.	12-3	11-2	10-6	9-9	16-2	14-8	13-10	12-10	20-8	18-9	17-8	16-5	25-1	22-10	21-4	19-1
	No. 1	12-0	10-11	10-4	9-7	15-10	14-5	13-7	12-4	20-3	18-5	16-9	15-0	24-8	21-4	19-6	17-5
	No. 2	11-10	10-9	10-1	9-3	15-7	14-2	13-0	11-8	19-10	17-5	15-11	14-3	23-4	20-3	18-6	16-6
	No. 3	9-11	8-7	7-10	7-0	12-7	10-11	10-0	8-11	15-5	13-4	12-2	10-11	17-10	15-5	14-1	12-7
Douglas Fir-South	Sel. Struc.	11-3	10-3	9-8	8-11	14-11	13-6	12-9	11-10	19-0	17-3	16-3	15-1	23-1	21-0	19-9	18-4
	No. 1	11-0	10-0	9-5	8-9	14-6	13-2	12-5	11-6	18-6	16-10	15-10	14-5	22-6	20-6	18-9	16-9
	No. 2	10-9	9-9	9-2	8-6	14-2	12-10	12-1	11-3	18-0	16-5	15-5	13-10	21-11	19-8	17-11	16-1
	No. 3	9-8	8-5	7-8	6-10	12-4	10-8	9-9	8-8	15-0	13-0	11-10	10-7	17-5	15-1	13-9	12-4
Hem-Fir	Sel. Struc.	11-10	10-9	10-1	9-4	15-7	14-2	13-4	12-4	19-10	18-0	17-0	15-9	24-2	21-11	20-8	19-2
	1 & Btr.	11-7	10-6	9-10	9-2	15-3	13-10	13-0	12-1	19-5	17-8	16-7	15-5	23-7	21-6	20-2	18-3
	No. 1	11-7	10-6	9-10	9-2	15-3	13-10	13-0	12-1	19-5	17-8	16-7	14-10	23-7	21-1	19-3	17-2
	No. 2	11-0	10-0	9-5	8-9	14-6	13-2	12-5	11-4	18-6	16-10	15-6	13-10	22-6	19-8	17-11	16-1
	No. 3	9-8	8-5	7-8	6-10	12-4	10-8	9-9	8-8	15-0	13-0	11-10	10-7	17-5	15-1	13-9	12-4
Spruce-Pine-Fir (South)	Sel. Struc.	11-0	10-0	9-5	8-9	14-6	13-2	12-5	11-6	18-6	16-10	15-10	14-8	22-6	20-6	19-3	17-11
	No. 1	10-9	9-9	9-2	8-6	14-2	12-10	12-1	11-3	18-0	16-5	15-5	14-1	21-11	19-11	18-3	16-3
	No. 2	10-5	9-6	8-11	8-3	13-9	12-6	11-9	10-10	17-6	15-11	14-9	13-3	21-4	18-9	17-2	15-4
	No. 3	9-3	8-0	7-3	6-6	11-8	10-1	9-3	8-3	14-3	12-4	11-3	10-1	16-6	14-4	13-1	11-8
Western Woods	Sel. Struc.	10-9	9-9	9-2	8-6	14-2	12-10	12-1	11-3	18-0	16-5	15-5	14-3	21-11	19-11	18-6	16-6
	No. 1	10-5	9-6	8-11	8-0	13-9	12-4	11-4	10-1	17-5	15-1	13-10	12-4	20-3	17-6	16-0	14-4
	No. 2	10-1	9-2	8-8	8-0	13-4	12-1	11-4	10-1	17-0	15-1	13-10	12-4	20-3	17-6	16-0	14-4
	No. 3	8-5	7-3	6-8	5-11	10-8	9-3	8-5	7-6	13-0	11-3	10-3	9-2	15-1	13-1	11-11	10-8

[1] *Spans for other loads are provided in WWPA's* ***Western Lumber Span Tables*** *(572). Spans for other grades and Western Cedars may be calculated with any of WWPA's design aids: the WWPA* ***Span Computer*** *(SR), a slide rule-style calculator;* ***DesignEasy,*** *a spreadsheet program for PDA devices; or the* ***Lumber Design Suite****, a spreadsheet program.*

Framing Lumber

CEILING JOIST SPANS[1]

Table **9**

20# LIVE LOAD 10# DEAD LOAD
L/240

Design Criteria: *Strength* - 10 lbs. per sq. ft. dead load plus 20 lbs. per sq. ft. live load.
Deflection - Limited in span in inches divided by 240 for live load only.

Species or Group	Grade	Span (feet and inches)															
		2 x 6				2 x 8				2 x 10				2 x 12			
		spacing on center															
		12"	16"	19.2"	24"	12"	16"	19.2"	24"	12"	16"	19.2"	24"	12"	16"	19.2"	24"
Douglas Fir-Larch	Sel. Struc.	16-4	14-11	14-0	13-0	21-7	19-7	18-5	17-2	27-6	25-0	23-7	21-3	33-6	30-2	27-6	24-8
	1 & Btr.	16-1	14-7	13-9	12-3	21-2	19-1	17-5	15-7	26-10	23-3	21-3	19-0	31-2	27-0	24-8	22-0
	No. 1	15-9	13-9	12-6	11-2	20-1	17-5	15-10	14-2	24-6	21-3	19-5	17-4	28-5	24-8	22-6	20-1
	No. 2	15-0	13-0	11-11	10-8	19-1	16-6	15-1	13-6	23-3	20-2	18-5	16-5	27-0	23-4	21-4	19-1
	No. 3	11-6	9-11	9-1	8-1	14-7	12-7	11-6	10-3	17-9	15-5	14-1	12-7	20-7	17-10	16-3	14-7
Douglas Fir-South	Sel. Struc.	14-9	13-5	12-8	11-9	19-6	17-9	16-8	15-6	24-10	22-7	21-3	19-9	30-3	27-6	25-10	23-4
	No. 1	14-5	13-1	12-1	10-9	19-0	16-9	15-3	13-8	23-7	20-5	18-8	16-8	27-4	23-8	21-7	19-4
	No. 2	14-1	12-8	11-7	10-4	18-6	16-0	14-8	13-1	22-7	19-7	17-10	16-0	26-3	22-8	20-9	18-6
	No. 3	11-2	9-8	8-10	7-11	14-2	12-4	11-3	10-0	17-4	15-0	13-8	12-3	20-1	17-5	15-11	14-3
Hem-Fir	Sel. Struc.	15-6	14-1	13-3	12-3	20-5	18-6	17-5	16-2	26-0	23-8	22-3	20-6	31-8	28-9	26-7	23-9
	1 & Btr.	15-2	13-9	12-11	11-9	19-11	18-2	16-8	14-11	25-5	22-3	20-4	18-2	29-10	25-10	23-7	21-1
	No. 1	15-2	13-7	12-4	11-1	19-10	17-2	15-8	14-0	24-3	21-0	19-2	17-1	28-1	24-4	22-2	19-10
	No. 2	14-5	12-8	11-7	10-4	18-6	16-0	14-8	13-1	22-7	19-7	17-10	16-0	26-3	22-8	20-9	18-6
	No. 3	11-2	9-8	8-10	7-11	14-2	12-4	11-3	10-0	17-4	15-0	13-8	12-3	20-1	17-5	15-11	14-3
Spruce-Pine-Fir (South)	Sel. Struc.	14-5	13-1	12-4	11-5	19-0	17-3	16-3	15-1	24-3	22-1	20-9	19-3	29-6	26-10	25-3	22-11
	No. 1	14-1	12-9	11-9	10-6	18-6	16-3	14-10	13-3	22-11	19-10	18-2	16-3	26-7	23-0	21-0	18-10
	No. 2	13-8	12-1	11-0	9-10	17-8	15-4	14-0	12-6	21-7	18-8	17-1	15-3	25-0	21-8	19-9	17-8
	No. 3	10-8	9-3	8-5	7-6	13-6	11-8	10-8	9-6	16-5	14-3	13-0	11-8	19-1	16-6	15-1	13-6
Western Woods	Sel. Struc.	14-1	12-9	11-11	10-8	18-6	16-6	15-1	13-6	23-3	20-2	18-5	16-5	27-0	23-4	21-4	19-1
	No. 1	13-0	11-3	10-4	9-3	16-6	14-3	13-0	11-8	20-2	17-5	15-11	14-3	23-4	20-3	18-6	16-6
	No. 2	13-0	11-3	10-4	9-3	16-6	14-3	13-0	11-8	20-2	17-5	15-11	14-3	23-4	20-3	18-6	16-6
	No. 3	9-8	8-5	7-8	6-10	12-4	10-8	9-9	8-8	15-0	13-0	11-10	10-7	17-5	15-1	13-9	12-4

[1] Refer to footnote at bottom of page 14.

STRUCTURAL DECKING SPANS

Table **10**

Spans for 4" to 12" wide lumber manufactured and used at a maximum moisture content of 19%.
Spans are given in feet-inches.

Species	2" Thick Decking												3" Thick Decking											
	Douglas Fir-Larch		Douglas Fir-South		Hem-Fir		Spruce-Pine-Fir (South)		Western Cedars		Western Woods		Douglas Fir-Larch		Douglas Fir-South		Hem-Fir		Spruce-Pine-Fir (South)		Western Cedars		Western Woods	
Grade	Sel.	Com.	Sel.	Com.	Sel.	Com.	Sel.	Com.	Sel.	Com.	Sel.	Com.	Sel.	Com.	Sel	Com.	Sel.	Com.	Sel.	Com.	Sel.	Com.	Sel.	Com.
FLOOR DECKING - 10 psf Dead Load / 40 psf Live Load (normal load)																						**L/480 Deflection Limit**		
Simple	5-6	5-5	5-1	4-11	5-2	5-1	5-1	4-10	4-8	4-7	4-10	4-8	9-3	9-0	8-6	8-3	8-8	8-6	8-6	8-1	7-10	7-7	8-1	7-10
Controlled Random	6-0	5-11	5-7	5-5	5-8	5-7	5-7	5-3	5-1	5-0	5-3	5-1	10-7	10-4	9-9	9-6	9-11	9-9	9-9	9-3	9-0	8-8	9-3	9-0
ROOF DECKING - 10 psf Dead Load / 20 psf Live Load (seven-day load)																						**L/240 Deflection Limit**		
Simple	8-9	8-7	8-1	7-10	8-3	8-1	8-1	7-8	7-5	7-3	7-8	7-5	14-7	14-4	13-5	13-1	13-9	13-5	13-5	12-9	12-5	12-0	12-9	12-5
Controlled Random	9-7	9-5	8-10	8-7	9-0	8-10	8-10	8-4	8-2	7-10	8-4	8-2	16-9	16-5	15-5	15-1	15-9	15-5	15-5	14-8	14-3	13-9	14-8	14-3
ROOF DECKING - 10 psf Dead Load / 30 psf Live Load (snow load)																						**L/240 Deflection Limit**		
Simple	7-8	7-6	7-1	6-11	7-3	7-1	7-1	6-8	6-6	6-4	6-8	6-6	12-9	12-6	11-9	11-6	12-0	11-9	11-9	11-2	10-10	10-6	11-2	10-10
Controlled Random	8-4	8-3	7-8	7-6	7-10	7-8	7-8	7-4	7-1	6-11	7-4	7-1	14-8	14-5	13-6	13-2	13-9	13-6	13-6	12-10	12-5	12-1	12-10	12-5
ROOF DECKING - 10 psf Dead Load / 40 psf Live Load (snow load)																						**L/240 Deflection Limit**		
Simple	7-0	6-10	6-5	6-3	6-7	6-5	6-5	6-1	5-11	5-9	6-1	5-11	11-7	11-5	10-8	10-5	10-11	10-8	10-8	10-2	9-10	9-6	10-2	9-10
Controlled Random	7-7	7-6	7-0	6-10	7-2	7-0	7-0	6-8	6-5	6-3	6-8	6-5	13-4	13-1	12-3	11-11	12-6	12-3	12-3	11-8	11-4	10-11	11-8	11-4

Spans for Dimension Lumber (8" & narrower) run-to-pattern as 2" and 3" decking may be used as follows:

No. 2 Grade

DF-L uses spans for Hem-Fir Selected Decking.
DF-S uses spans for Western Woods Selected Decking.
H-F uses spans for Douglas Fir-South Commercial Decking.
SPF^{S} uses spans for Western Woods Commercial Decking.
Other species groups use spans for Western Cedars Commercial Decking.

No. 3 Grade (for Roof Decking: use Simple arrangement spans for both Simple and Controlled Random arrangements.)

DF-L uses spans for Douglas Fir-South Selected Decking.
DF-S uses spans for Western Cedars Selected Decking.
H-F uses spans for Western Woods Selected Decking.
SPF^{S} uses spans for Western Cedars Commercial Decking with reductions of 3" for 2" -Decking, and 5" for 3" -Decking

Framing Lumber

PROPERTIES OF STANDARD DRESSED SIZES (S4S)

Certain mathematical expressions of the properties or elements of sections are used in computing the values of structural members of various shapes for the various conditions under which they are subjected to stress. The properties or elements of sections of standard sizes of joists, planks, beams, stringers, posts, timbers and decking are given in the following tables.

NEUTRAL AXIS, X–X in the diagrams, in the cross section of a beam or column in a state of flexure, is the line on which there is neither tension nor compression.

In the following tables, which show the properties of the rectangular and square sections of lumber, the neutral axis has been assumed as perpendicular to the depth of the section at its center, the depth "h" being parallel to and in the direction of the application of the force or load.

MOMENT OF INERTIA, *I*, of the cross section of a beam is the sum of the products of each of its elementary areas by the square of their distance from the neutral axis of the section.

SECTION MODULUS, *S*, is the moment of inertia divided by the distance from the neutral axis to the extreme fiber of the section.

CROSS SECTION is a section taken through the member perpendicular to its longitudinal axis.

SECTION PROPERTIES OF PLANKS

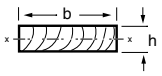


Table **11**

Nominal Size in Inches $b \times h$	Surfaced Size for Design in Inches $b \times h$	Area (A) $A = bh$ (in²)	Section Modulus (S) $S = \frac{bh^2}{6}$ (in³)	Moment of Inertia (I) $I = \frac{bh^3}{12}$ (in⁴)	Board Feet per Lineal Foot of Piece
3 × 2	2.5 × 1.5	3.75	0.938	0.703	0.50
4 × 2	3.5 × 1.5	5.25	1.312	0.984	0.67
6 × 2	5.5 × 1.5	8.25	2.062	1.547	1.00
8 × 2	7.25 × 1.5	10.88	2.719	2.039	1.33
10 × 2	9.25 × 1.5	13.88	3.469	2.602	1.67
12 × 2	11.25 × 1.5	16.88	4.219	3.164	2.00
4 × 3	3.5 × 2.5	8.75	3.646	4.557	1.00
6 × 3	5.5 × 2.5	13.75	5.729	7.161	1.50
8 × 3	7.25 × 2.5	18.12	7.552	9.440	2.00
10 × 3	9.25 × 2.5	23.12	9.635	12.044	2.50
12 × 3	11.25 × 2.5	28.12	11.719	14.648	3.00
14 × 3	13.25 × 2.5	33.12	13.802	17.253	3.50
16 × 3	15.25 × 2.5	38.12	15.885	19.857	4.00
6 × 4	5.5 × 3.5	19.25	11.229	19.651	2.00
8 × 4	7.25 × 3.5	25.38	14.802	25.904	2.67
10 × 4	9.25 × 3.5	32.38	18.885	33.049	3.33
12 × 4	11.25 × 3.5	39.38	22.969	40.195	4.00
14 × 4	13.25 × 3.5	46.38	27.052	47.341	4.67
16 × 4	15.25 × 3.5	53.38	31.135	54.487	5.33

SECTION PROPERTIES OF DECKING (per foot of width)

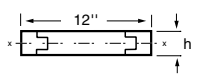


Table **12**

Nominal Size in Inches h	Surfaced Size for Design in Inches $b \times h$	Area (A) $A = bh$ (in²)	Section Modulus (S) $S = \frac{bh^2}{6}$ (in³)	Moment of Inertia (I) $I = \frac{bh^3}{12}$ (in⁴)	Board Feet per Lineal Foot of Piece
2	12 × 1.5	18.00	4.50	3.375	2.00
3	12 × 2.5	30.00	12.50	15.625	3.00
4	12 × 3.5	42.00	24.50	42.875	4.00

SECTION PROPERTIES OF JOISTS AND BEAMS

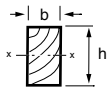


Table **13**

Nominal Size in Inches $b \times h$	Surfaced Size for Design in Inches $b \times h$	Area (A) $A = bh$ (in²)	Section Modulus (S) $S = \frac{bh^2}{6}$ (in³)	Moment of Inertia (I) $I = \frac{bh^3}{12}$ (in⁴)	Board Feet per Lineal Foot of Piece
2 × 2	1.5 × 1.5	2.25	0.562	0.422	0.33
2 × 3	1.5 × 2.5	3.75	1.56	1.95	0.50
2 × 4	1.5 × 3.5	5.25	3.06	5.36	0.67
2 × 6	1.5 × 5.5	8.25	7.56	20.80	1.00
2 × 8	1.5 × 7.25	10.88	13.14	47.63	1.33
2 × 10	1.5 × 9.25	13.88	21.39	98.93	1.67
2 × 12	1.5 × 11.25	16.88	31.64	177.98	2.00
2 × 14	1.5 × 13.25	19.88	43.89	290.78	2.33
3 × 3	2.5 × 2.5	6.25	2.60	3.26	0.75
3 × 4	2.5 × 3.5	8.75	5.10	8.93	1.00
3 × 6	2.5 × 5.5	13.75	12.60	34.66	1.50
3 × 8	2.5 × 7.25	18.12	21.90	79.39	2.00
3 × 10	2.5 × 9.25	23.12	35.65	164.89	2.50
3 × 12	2.5 × 11.25	28.12	52.73	296.63	3.00
3 × 14	2.5 × 13.25	33.12	73.15	484.63	3.50
3 × 16	2.5 × 15.25	38.12	96.90	738.87	4.00
4 × 4	3.5 × 3.5	12.25	7.15	12.51	1.33
4 × 6	3.5 × 5.5	19.25	17.65	48.53	2.00
4 × 8	3.5 × 7.25	25.38	30.66	111.15	2.67
4 × 10	3.5 × 9.25	32.38	49.91	230.84	3.33
4 × 12	3.5 × 11.25	39.38	73.83	415.28	4.00
4 × 14	3.5 × 13.25	46.38	102.41	678.48	4.67
4 × 16	3.5 × 15.25	53.38	135.66	1034.42	5.33
6 × 6	5.5 × 5.5	30.25	27.73	76.26	3.00
6 × 8	5.5 × 7.5	41.25	51.56	193.36	4.00
6 × 10	5.5 × 9.5	52.25	82.73	392.96	5.00
6 × 12	5.5 × 11.5	63.25	121.23	697.07	6.00
6 × 14	5.5 × 13.5	74.25	167.06	1127.67	7.00
6 × 16	5.5 × 15.5	85.25	220.23	1706.78	8.00
6 × 18	5.5 × 17.5	96.25	280.73	2456.38	9.00
6 × 20	5.5 × 19.5	107.25	348.56	3398.48	10.00
8 × 8	7.5 × 7.5	56.25	70.31	263.67	5.33
8 × 10	7.5 × 9.5	71.25	112.81	535.86	6.67
8 × 12	7.5 × 11.5	86.25	165.31	950.55	8.00
8 × 14	7.5 × 13.5	101.25	227.81	1537.73	9.33
8 × 16	7.5 × 15.5	116.25	300.31	2327.42	10.67
8 × 18	7.5 × 17.5	131.25	382.81	3349.61	12.00
8 × 20	7.5 × 19.5	146.25	475.31	4634.30	13.33
8 × 22	7.5 × 21.5	161.25	577.81	6211.48	14.67
8 × 24	7.5 × 23.5	176.25	690.31	8111.17	16.00
10 × 10	9.5 × 9.5	90.25	142.90	678.76	8.33
10 × 12	9.5 × 11.5	109.25	209.40	1204.03	10.00
10 × 14	9.5 × 13.5	128.25	288.56	1947.80	11.67
10 × 16	9.5 × 15.5	147.25	380.40	2948.07	13.33
10 × 18	9.5 × 17.5	166.25	484.90	4242.84	15.00
10 × 20	9.5 × 19.5	185.25	602.06	5870.11	16.67
10 × 22	9.5 × 21.5	204.25	731.90	7867.88	18.33
12 × 12	11.5 × 11.5	132.25	253.48	1457.51	12.00
12 × 14	11.5 × 13.5	155.25	349.31	2357.86	14.00
12 × 16	11.5 × 15.5	178.25	460.48	3568.71	16.00
12 × 18	11.5 × 17.5	201.25	586.98	5136.07	18.00
12 × 20	11.5 × 19.5	224.25	728.81	7105.92	20.00
12 × 22	11.5 × 21.5	247.25	885.98	9524.28	22.00
12 × 24	11.5 × 23.5	270.25	1058.48	12437.13	24.00

Framing Lumber

SPECIFYING ROUGH CARPENTRY MATERIALS

All lumber should be gradestamped by an agency certified by the Board of Review of the American Lumber Standard Committee, Inc. and manufactured in accordance with *Product Standard PS 20*, published by the U.S. Department of Commerce.

The following guidelines are intended to assist the designer and specifier in establishing the most economical and efficient use of solid lumber products and to eliminate potential misunderstandings between specifier and supplier.

A specification should include all species suited to the job. This broadens availability which can lower costs. Specify standard grades as described in WWPA's *Western Lumber Grading Rules*. Consider all grades suitable for the intended use. For economy in construction, it is recommended that the lowest grade suited to a job be specified.

Verify availability of species and grades with local suppliers. Not all species, grades or patterns are available in all locations.

Structural design values vary depending on size, grade and species. Values assigned to lumber 2" to 4" (nominal) in thickness are assigned to the dry size. Unseasoned lumber is manufactured oversized so that when it reaches 19% moisture content it will be approximately the same size as the dry (S-DRY or KD) size*. Therefore, when unseasoned (S-GRN) lumber is shipped, the same design values that are assigned and used for dry lumber will apply. Design values assigned to lumber 5x5 and larger are assigned to the unseasoned (S-GRN) green size.

2" to 4" thick by 2" to 4" wide Framing Lumber - The most widely available grades are STANDARD & BETTER (STAND & BTR) and STUD, in all of the commercial softwood species.

These grades are appropriate for most general wall framing applications.

STUD, STAND & BTR, and the other grades (CONSTRUCTION and UTILITY) are available in any conventional length. Dimension lumber grades apply to both solid sawn and certified structural-glued lumber.

UTILITY, in any commercial softwood species, may be used for plates, blocking and some walls. UTILITY grade lumber provides economical construction where good appearance of framing lumber is not needed. Building codes permit the use of UTILITY grade lumber in lightly loaded structural applications.

When small posts or beams (2x4, 4x4) require specific design values, refer to Table 1, page 6, to determine appropriateness of CONSTRUCTION, STANDARD and UTILITY grades. Specify according to BASE VALUES. Specified BASE VALUES are then modified by adjustments for engineering analysis.

Some 2x2s through 4x4s may require higher design values than available in these grades. In this case, refer to Table 1, page 6, in SELECT STRUCTURAL, NO. 1 & BTR, NO. 1, NO. 2 and NO. 3 grades. Specify BASE VALUE structural values. Adjust BASE VALUES from Table 1, page 6, for engineering analysis. Or refer to the design values for Machine Stress-Rated (MSR) lumber in Table 3, page 10.

Specifying MSR lumber is very straightforward because it is generally marketed by strength and stiffness values, F_b and E. When ordering, specify machine-rated (MSR), gradestamped lumber and list the strength value (F_b) and corresponding modulus of elasticity (E) values, nominal sizes and lengths required. Species should only be specified when horizontal shear (F_v), compression perpendicular-to-grain ($F_{c\perp}$) or specific gravity are controlling.

Some MSR lumber producers provide voluntary daily quality control for tension (F_t) in addition to the mandatory F_b and E testing. When this additional level of quality control is provided, the F_t value will appear on the grade stamp (in addition to F_b and E).

2" to 4" thick by 5" and wider Framing Lumber - Joists, rafters and small beams should be specified by minimum required F_b and E BASE VALUES. Refer to Table 1, page 6, with Adjustment Factors, page 7. Whenever possible, design values should be based on NO. 2 grade values of locally available species as most material is marketed NO. 2 & BTR. NO. 1 & BTR J&P may be available in some markets in some species. Higher values should only be used for longer spans or higher loads. Lightly loaded structures should take advantage of the economy of NO. 3 grade. Machine Stress-Rated and certified structural-glued lumber can be used as well.

Where engineering analysis permits, 2x6 studs can be NO. 3 or STUD grade.

5"x5" and larger, Beams/Stringers and Posts/Timbers - The grades are SELECT STRUCTURAL, NO. 1, NO. 2 or NO. 3 grade. Grade and species should be determined by required design values. Refer to Tables 4 and 5, page 11, with appropriate adjustments for conditions of use. No design values are assigned to NO. 3 grade. Where a maximum dimensional stability is a requirement, specify Free of Heart Center (FOHC), realizing costs will be increased and availability limited.

Structural Decking - The grades are SELECTED DECKING and COMMERCIAL DECKING. Decking may be manufactured either at 19% (S-DRY or KD) or 15% (MC15 or KD15) moisture content. Decking should be allowed to acclimate to its surrounding atmosphere prior to installation. Refer to "Seasoning Lumber" on page 20. Edge gluing is not generally recommended. MC15 or KD15 will minimize shrinkage for exposed applications and may be available at an increased cost. Check with local suppliers.

Some tongue-and-groove product is manufactured to pattern from NO. 2 & BTR or NO. 3, 2x6 or 2x8 framing lumber. It is generally used for concealed subfloors in deck and girder construction. Refer to Table H, page 9, for Depth Effect increase for Decking grades. (Table D, page 9, is for Base Value Dimension grades.)

Appearance of Framing Material - Where structural material is to receive a natural finish and appearance is a factor, the top grade in the respective size category may be specified. An Appearance classification that provides a higher aesthetic level for structural lumber also is available. Designated by the term APP included on the grade mark, this lumber provides the same level of structural performance as the applicable NGR grade, but with added restrictions on manufacture, wane, skip and warp. While such a specification may yield structural products of good appearance, it is important to recognize that structural grades of lumber are graded primarily for strength rather than appearance; even in the highest grades visual imperfections are not eliminated. The added expense and limited availability of the visually perfect structural grades should be evaluated. If limited quantities are required it may be beneficial to specify hand-selected material, rather than the top grade, dictating which visual characteristics are unacceptable.

***Note:** S-DRY (or KD) and S-GRN lumber should not be mixed in a horizontal framing system, e.g. floor joists; and the same applies to a vertical framing system, e.g. wall studs. While both DRY and GRN are of the same strength and both will eventually reach the same size, the two will acclimate at different rates before achieving equilibrium with the atmosphere.

Appearance Lumber

The lumber grades in this category are intended for applications where strength is not the primary consideration. Grading is by visual inspection and is a judgment of appearance and suitability to end use rather than of strength. Natural characteristics and manufacturing imperfections are taken into account in the assigning of grades. Lumber in this category is often generically referred to as Board lumber, although the category also includes run-to-pattern products and Patio Decking. The highest grades of Appearance lumber are seldom gradestamped, unless on the back or ends, as the grade stamp would deface the product. The general purpose grades, such as COMMONS and ALTERNATE BOARDS, are generally stamped. Refer to page 20 for additional information on grade stamps, moisture content and specifying Appearance lumber.

Many of the Western lumber species are grown, harvested, manufactured and shipped together in "Marketing Categories." In addition to the species combinations that share like structural characteristics, Board lumber is often available in combinations related to like appearance characteristics. Refer to the Marketing Categories species list on page 4 and the WWPA *Western Lumber Grading Rules* for additional information.

The grades and recommended end uses for Appearance lumber are explained in Table 14. Standard sizes are explained in Table 15. Refer to page 19 for information on the Radius-edged Patio Decking grades.

APPEARANCE LUMBER GRADES Table **14**

	Product	Grades[1]	Equivalent Grades in Idaho White Pine	WWPA Grading Rules Section Number
Highest Quality Appearance Grades	Selects *(all species)*	B & BTR SELECT	SUPREME	10.11
		C SELECT	CHOICE	10.12
		D SELECT	QUALITY	10.13
	Finish *(usually available only in Doug Fir and Hem-Fir)*	SUPERIOR		10.51
		PRIME		10.52
		E		10.53
	Special Western Red Cedar Pattern[2] Grades	CLEAR HEART		20.11
		A GRADE		20.12
		B GRADE		20.13
General Purpose Grades	Common Boards (WWPA Rules) *(primarily in pines, spruces, and cedars)*	1 COMMON	COLONIAL	30.11
		2 COMMON	STERLING	30.12
		3 COMMON	STANDARD	30.13
		4 COMMON	UTILITY	30.14
		5 COMMON	INDUSTRIAL	30.15
	Alternate Boards (WCLIB Rules) *(primarily in Doug Fir and Hem-Fir)*			**WCLIB[3,4]**
		SELECT MERCHANTABLE		118-a
		CONSTRUCTION		118-b
		STANDARD		118-c
		UTILITY		118-d
		ECONOMY		118-e
	Special Western Red Cedar Pattern[2] Grades			**WCLIB[3]**
		SELECT KNOTTY		111-e
		QUALITY KNOTTY		111-f

1 Refer to WWPA's *Vol 2, Western Wood Species* book for full-color photography and to WWPA's *Natural Wood Siding* for complete information on siding grades, specification and installation.
2 "PATTERN" includes finish, paneling, ceiling and siding grades.
3 West Coast Lumber Inspection Bureau's *West Coast Lumber Standard Grading Rules*.
4 Also found in WWPA's *Western Lumber Grading Rules*.

BOARD LUMBER

Grades/End Uses - Select grades are determined from the better side or face and are used for applications where only the finest appearance is appropriate. B & BTR is virtually clear and very limited in availability. The appearance of C SELECT ranks only slightly less than B & BTR SELECT. D SELECT is suitable where the requirements for finishing are less exacting.

Finish grades are determined from the better side or face and from both edges on pieces 5" and narrower and from the better side or face and one edge on pieces 6" and wider. SUPERIOR is virtually clear. PRIME grade exhibits fine appearance although slightly less restrictive than SUPERIOR. E grade is intended for ripping and cross-cutting to obtain small pieces of PRIME or better quality.

The highest quality, premium cedar grades are typically run-to-pattern into siding or paneling products and may be graded to either the surfaced or a saw-textured side. CLEAR VG HEART is intended for use where only the highest quality is indicated. The exposed width is all heartwood and free from imperfections. A grade allows only minor imperfections and is of fine appearance. Square-edged cedar boards are generally manufactured in SELECT grades.

Common Board grades are determined from the better face and are varying qualities of knotty material. 1 and 2 COMMON are usually sold as 2 & BTR COMMON and intended for paneling, shelving and other uses where a fine appearance in knotty material is desirable. 3 COMMON is also widely used for siding, paneling and shelving as well as for fences, boxes, crating, sheathing and industrial applications.
4 COMMON is used for general construction such as subfloors, roof and wall sheathing, concrete forms, low-cost fencing and crating.
5 COMMON is intended for economy-governed applications.

Alternate Board grades are determined from the better face. SELECT MERCHANTABLE is intended for use in housing and light construction where it is exposed as paneling, shelving and where knotty type lumber of fine appearance is desirable. CONSTRUCTION is used for spaced sheathing, let-in bracing, fences, boxes, crating and industrial applications. The uses for STANDARD are similar to a 4 COMMON, as described above.

Special Western Red Cedar general purpose grades (SELECT KNOTTY or QUALITY KNOTTY) are similar in appearance to 2 COMMON and 3 COMMON, and are widely used for siding and landscape applications. Knot size and quality are defined in the grading rules; sound, tight knots do not adversely affect performance. Dry knotty siding must not exceed 19% moisture content and it may be specified to MC15 or KD15. Knotty siding also is sometimes manufactured unseasoned.

RUN-TO-PATTERN PRODUCTS

Board lumber is the starting material for many products that are run-to-pattern, such as paneling, siding, flooring, ceiling and partition material. In many cases, the grade of the material that has been run-to-pattern reflects the grade of the starting material, adhering to similar requirements for allowable characteristics.

Refer to WWPA's *Natural Wood Siding-Technical Guide* (TG-8) for comprehensive information on WWPA and WCLIB siding grades, patterns, specification and installation. Refer to WWPA's *Standard Patterns* (G-16) for paneling, flooring, ceiling, partition (and siding) patterns in profile with dimensions. Contact the Wood Moulding and Millwork Producers Association (**www.wmmpa.com**) for moulding and trim patterns in profile.

Appearance Lumber

RADIUS-EDGED PATIO DECKING

Grades/End-Uses - Western Patio Decking is manufactured to be used flat-wise for load-bearing applications where spans are maximum 16" on center. Ponderosa Pine species graded to the WWPA rules for Patio Decking is span rated for 24" on center. This product offers an excellent option for decks and landscaping applications where Structural Decking or other dimension products would not be sufficiently refined in appearance to suit the end use.

Its thin profile, with oversized eased edges, makes it suitable for outdoor and garden applications such as patio decks, benches, railings, trim and fencing. It may be used for planters and shelving where stock thinner than regular 2" decking is desirable.

Patio Decking is available in two grades: PATIO 1 and PATIO 2.

PATIO 1 is similar in appearance (in terms of limitations on natural characteristic but allowing fewer restrictions with regards to manufacturing imperfections) to a 2 & BTR COMMON; whereas PATIO 2 is similar in appearance to the upper end of the 3 COMMON. Refer to page 18 for a description of the COMMON grades.

Patio Decking is manufactured primarily in Ponderosa Pine (which has a cell structure very receptive to preservative pressure treating) and the Western Cedars (which are naturally durable). The Patio grades are gradually becoming available in other Western lumber species as well.

Both grades may be manufactured in two sizes. Refer to Table 16.

Nailing - Pre-drill holes near the ends of each piece. Use only non-corrosive (stainless steel, high strength aluminum or hot-dipped galvanized) 10d (3") nails or 8d (minimum) deck screws. Use two nails per piece driven one inch in from each edge. Ring- or spiral-shank nails will provide additional holding capacity. Pre-finish edges, ends and surfaces for best results.

Refer to “Seasoning Lumber” on page 20 for additional information.

STANDARD SIZES
PATIO DECKING

Table **16**

PATIO 1 & 2	Surfaced DRY	Surfaced GRN
1/4″ radius edge	1″ × 5 1/2″	1 1/32″ × 5 5/8″
3/8″ radius edge	1 5/32″ × 5 1/2″	1 3/16″ × 5 5/8″

STANDARD SIZES - APPEARANCE LUMBER

Table **15**

Nominal & Dressed (Based on *Western Lumber Grading Rules*)

Product	Description	Nominal Size Thickness inch	Nominal Size Width inch	Dry Dressed (surfaced) Size Thickness inch	Thickness mm	Width inch	Width mm	Lengths feet
SELECTS AND COMMONS	S1S, S2S, S4S, S1S1E, S1S2E	4/4 5/4 6/4 7/4 8/4 9/4 10/4 11/4 12/4 16/4	2 3 4 5 6 7 8 & wider	3/4 1 5/32 1 13/32 1 19/32 1 13/16 2 3/32 2 3/8 2 9/16 2 3/4 3 3/4	19 29 36 40 46 53 60 65 70 95	1 1/2 2 1/2 3 1/2 4 1/2 5 1/2 6 1/2 3/4 off nominal	38 64 89 114 140 165 19 off nominal	6′ (183 cm) and longer in multiples of 1′ (31 cm), except Douglas Fir and Larch Selects shall be 4′ (122 cm) and longer with 3% of 4′ (122 cm) and 5′ (152 cm) permitted.
FINISH AND ALTERNATE BOARD GRADES	S1S, S2S, S4S, S1S1E, S1S2E	3/8 1/2 5/8 3/4 [1] 1 [1] 1 1/4 [1] 1 1/2 [1] 1 3/4 2 2 1/2 3 3 1/2 4	2 3 4 5 6 7 8 & wider	5/16 7/16 9/16 5/8 3/4 1 1 1/4 1 3/8 1 1/2 2 2 1/2 3 3 1/2	8 11 14 16 19 25 32 35 38 51 64 76 89	1 1/2 2 1/2 3 1/2 4 1/2 5 1/2 6 1/2 3/4 off nominal	38 64 89 114 140 165 19 off nominal	3′ (91 cm) and longer. In SUPERIOR grade, 3% of 3′ (91 cm) and 4′ (122 cm) and 7% of 5′ (152 cm) and 6′ (183 cm) are permitted. In PRIME grade 20% of 3′ (91 cm) to 6′ (183 cm) is permitted.

[1] These sizes apply only to WCLIB Alternate Board grades.

Abbreviations: S1S—Surfaced one side; S2S—Surfaced two sides; S4S—Surfaced four sides; S1S1E—Surfaced one side, one edge; S1S2E—Surfaced one side, two edges

Note on Metrics: Metric equivalents are provided for surfaced (actual) sizes.

Appearance Lumber

SPECIFYING FINISH CARPENTRY MATERIALS

A specification for a Finish or Board lumber grade should include a reference to the section number, title and edition of the grading rules from which it is written. In other words, if specifying from Section 21.11, Special Western Red Cedar Rules, WWPA *Western Lumber Grading Rules 05*, so state.

Grain patterns, when desired, can also be specified for Selects, Finish and Special Western Red Cedar grades. Three categories are available: vertical grain (VG), flat grain (FG) or a shipment of both VG and FG, generally referred to as mixed grain (MG). The most readily available and least costly is mixed grain. Unless otherwise specified, siding, paneling and finish boards are shipped with mixed grain. Stair treads and stepping should be vertical grain as it is more durable.

Board Lumber in Combination with Rough Carpentry Materials - Boards, basically, are 1" nominal thickness. Board grades used in conjunction with rough carpentry materials are generally controlled by building code requirements, and the grades are selected from the Common or Alternate Board grades listed in the appearance lumber grades chart in Table 14, page 18.

As an example, major model building codes recognize 3 COMMON or STANDARD grades as equal minimum grades for spaced roof sheathing even though there are differences in grading characteristics. Verify local building code requirements and dealer availability prior to specifying.

Seasoning Lumber - Once in place, lumber adjusts to its surrounding atmospheric conditions. In a covered structure, lumber will stabilize at approximately 6% to 12% moisture content. Size will vary approximately 1% for each 4% change in moisture content. Thus, it is important that all finish materials be stacked and stickered, in the room where they will be applied, for 7 to 10 days prior to installation. 2x decking material should be allowed to acclimate for 14 to 21 days prior to installation. The lumber should be stored off the ground, well ventilated and loosely covered. The lumber will then stabilize its moisture content for its permanent location. Staining or priming, where economically feasible, should be done before installation. Refer to WWPA's *Paneling Basics* (A-3), *Natural Wood Siding-Technical Guide* (TG-8) and *Lumber Storage* (TG-5) for additional information.

Moisture Content - WWPA Finish, Select and Special Western Red Cedar Grades are shipped seasoned as follows: S-DRY (or KD) or MC15 (or KD15) with at least 85 percent of items not exceeding 12% in moisture content and no portion exceeding 15% moisture content. Appearance grades of Western lumber are not shipped S-GRN (with a moisture content above 19% at the time of surfacing) except in some of the knotty grades. Refer to page 5 for additional information on moisture content designations in the grade stamp and to WWPA's *Natural Wood Siding-Technical Guide* (TG-8) for recommendations on handling unseasoned siding products.

Interior and Exterior Trim and Finish Board Materials - Select from appearance grades as indicated in Table 14, page 18, and described in the WWPA *Western Lumber Grading Rules*.

Refer to the WWPA publication *Vol. 2: Western Wood Species* (11) for color photographs of Select, Finish, Common and Alternate Board grades in many Western lumber species.

Wood Siding and Paneling Materials - The publications *Natural Wood Siding–Technical Guide* (TG-8) and *Paneling Basics* (A-3) offer information on selecting pattern type and grade, and summarize installation and handling requirements.

After a general pattern type has been selected, the pattern number should be specified from the WWPA publication *Standard Patterns* (G-16).

When a saw-textured face is desired, the face to be textured and the type of texture (band sawn, rough sawn, circular sawn) should be specified.

A siding specification should include WWPA's industry recommendations for acclimatization, backpriming, nailing and finishing. Refer to WWPA's *Natural Wood Siding–Technical Guide* (TG-8) for details. A checklist and moisture content guidelines are provided below for convenience.

MOISTURE CONTENT GUIDELINES

Uses of Wood	Recommended Moisture Content at Time of Installation[1]					
	Most Areas of the U.S.		Dry, Southwestern States		Damp, Warm Southeastern Coastal Areas	
Interior: Furniture, Woodwork, Flooring and Wood Trim	**Average[1]**	**Individual Pieces**	**Average[1]**	**Individual Pieces**	**Average[1]**	**Individual Pieces**
	8%	6-10%	6%	4-9%	11%	8-13%
Exterior: Siding, Trim, Sheathing and Laminated Timbers	**Average[1]**	**Individual Pieces**	**Average[1]**	**Individual Pieces**	**Average[1]**	**Individual Pieces**
	12%	9-14%	9%	7-12%	12%	9-14%

[1] To obtain a realistic average, test at least 10% of each item, i.e. 10% of the siding pieces, 10% of the trim pieces and random checks of the sheathing material. It is particularly important to check the sheathing prior to the siding application if it has become wet after it was installed.

Source: USDA Wood Handbook, 1999, Table 12-2, Forest Products Laboratory Report FPL-GTR-113.

SIDING OR PANELING MATERIAL SPECIFICATION

Checklist **6**

- ☐ Select species suited to the project.
- ☐ List grade names, paragraph numbers and rules-writing agency. *(Refer to Table 14.)*
- ☐ Specify surface texture for exposed face.
- ☐ Specify moisture content suited to project.
- ☐ If gradestamped, specify lumber be stamped on back or ends. (WWPA's *Specifying Lumber* [A-2] offers additional information.)
- ☐ Specify VG (vertical grain) if appropriate and available.
- ☐ Specify pattern and size. (WWPA's *Standard Patterns* [G-16] offers additional information.)
- ☐ Specify installation, nailing and finishing. (WWPA's *Natural Wood Siding-Technical Guide* [TG-8] offers additional information.)

Industrial Lumber

This broad category of Western lumber products includes structural products, some with applied design values, products for remanufacturing purposes and non-structural, miscellaneous products for a variety of specific applications. Classifications and grades are indicated in the chart below.

INDUSTRIAL LUMBER

Structural Products	Remanufacturing Products (non-structural)	Non-Structural Products
Mining Timbers	Boards	Gutter
Scaffold Plank	Factory	Picket
Foundation Lumber	Moulding	Lath
Stress-rated Boards	Shop	Battens
		Stepping

STRUCTURAL PRODUCTS

Mining Timbers are designed primarily for use as shoring and bracing materials in mines and tunnels. The grades are designed for serviceability, not necessarily appearance. There are two grades: NO. 1 MINING and NO. 2 MINING. Both are graded full length. No design values are assigned. Nominal sizes are 5" and thicker, 5" and wider. Refer to Sections 81.11 and 81.12 in the WWPA *Western Lumber Grading Rules* for additional information.

Scaffold Plank is shipped rough and unseasoned in Douglas Fir-Larch, 1¼" and thicker, 8" and wider, in two grades (SCAFFOLD NO. 1 and SCAFFOLD NO. 2) with applied design values.

SCAFFOLD PLANK DESIGN VALUES Table **17**

Design Values—For Flatwise Use[1]

Thickness	Grade	Extreme Fiber Stress in Bending (F_b) in psi	Modulus of Elasticity (E) in psi
2″ and less	No. 1	2350	1,800,000
	No. 2	2200	1,800,000
These values apply to dry use conditions. For wet use conditions, these values shall be multiplied by 0.86 for F_b and 0.97 for E.			
3″	No. 1	1800	1,600,000
	No. 2	1650	1,600,000
These values apply to both dry and wet use conditions.			

[1] See Sections 100.00 through 180.00 in the *Western Lumber Grading Rules* for information about these values.

Bending Stresses (F_b) for Scaffold Plank grades have incorporated a scaffold use factor according to the American National Standards Institute (ANSI) *Standard A10.8*. This factor modifies the allowable bending stresses to the equivalent safety level of four times the design load without failure.

Foundation Lumber is occasionally used for sill plates. It is available only in Western Red Cedar and Incense Cedar, in nominal sizes 2" and thicker, 4" and wider. There is only one grade: FOUNDATION. It is selected from heartwood (naturally decay resistant) and must be free of heart center and free of sapwood. It is manufactured rough sawn or surfaced. Where surfaced, the sizes are the same as for Dimension lumber or Timbers, Table 6, page 13. Refer to Section 54.00 of WWPA's *Western Lumber Grading Rules* for additional information.

Stress-Rated Boards - Stress-Rated boards are available from Western lumber manufacturers in all species to provide a range of products suitable for special applications when Board lumber is to have applied design values. Several such uses include light trusses, belt rails, horizontal bracing, rafters and box beams for mobile and factory built homes. Design values are the same as those shown in Table 1, page 6. Apply all appropriate adjustments for BASE VALUES, Tables A-G. When Stress-Rated Boards are gradestamped, the grade name or number for the Dimension grades will be shown on the grade stamp along with "SRB" designating Stress-Rated Board. Refer to Section 30.60 of the *Western Lumber Grading Rules* for additional information.

STANDARD SIZES[1] STRESS-RATED BOARDS Table **18**

	Nominal	Surfaced Unseasoned inch	Surfaced Unseasoned mm	Surfaced Dry inch	Surfaced Dry mm
Thickness	1"	25/32	20	¾	19
	1¼"	1 1/32	26	1	25
	1½"	1 9/32	33	1¼	32
Widths	2"	1 9/16	40	1½	38
	3"	2 9/16	65	2½	64
	4"	3 9/16	90	3½	89
	5"	4 5/8	117	4½	114
	6"	5 5/8	143	5½	140
	8" and wider	½ off nominal	13 off nominal	¾ off nominal	19 off nominal

[1] Standard lengths are 6′ (183 cm) and longer in multiples of 1′ (31 cm).

Note on Metrics: Metric equivalents are provided for surfaced (actual) sizes.

REMANUFACTURING PRODUCTS

Factory and Shop Grades provide the remanufacturer with an opportunity to buy industrial lumber, intended for the recovery of clear pieces, at an economical price. These grades, available primarily in Douglas Fir, Hem-Fir, Ponderosa Pine and Sugar Pine, are especially well suited for remanufacture to obtain clear, standard-size cuttings that are based on typical U.S. joinery and millwork cutting sizes. Grades include MOULDING STOCK, CLEAR DOOR, FACTORY SELECT, (NO. 3 CLEAR), NO. 1 SHOP, NO. 2 SHOP, NO. 3 SHOP, and FINGER-JOINT SHOP COMMON. Refer to WWPA's *Vol. 3: Western Wood Species* book on *Factory Lumber* (12) or the *Western Lumber Grading Rules* for additional information. Standard sizes are shown in Table 19 on the following page.

Industrial Lumber

STANDARD SIZES - FACTORY LUMBER
NOMINAL AND DRESSED

Table **19**

Product	Description	Nominal Size			Dry Dressed (surfaced) Size			Lengths
		Thickness	Width		Thickness		Face Width	
			inch		inch	mm		
		4/4	1		¾	19		
FACTORY	S2S	5/4	1¼	See individual	1 5/32	29	Usually	6' (182 cm)
AND	(Surfaced	6/4	1½	descriptions	1 13/32	36	sold	and longer,
SHOP	two sides)	7/4	1¾	WWPA's	1 19/32	40	random	generally
LUMBER		8/4	2	*Western Lumber*	1 13/16	46	width	shipped in
		10/4	2½	*Grading Rules*	2 3/8	60		multiples of
		12/4	3		2 ¾	70		2' (61 cm)
		16/4	4		3 ¾	95		

Note on Metrics: Metric equivalents are provided for surfaced (actual) sizes.

NON-STRUCTURAL PRODUCTS

Gutter (WCLIB grade) is available in some Western species and shipped in a number of patterns. It is available in one grade, GUTTER, and usually (but not necessarily) measures 4" x 5" x 20'. Pieces of this grade are of sound wood and are water tight. Refer to Paragraph 112 in WWPA *Western Lumber Grading Rules*.

Pickets (WCLIB grade) are available in any Western species and are shipped kiln-dried (KD) or unseasoned (S-GRN). Grades, NO. 1 and NO. 2, are based on a piece 1" x 3" x 4'. Standard sizes are shown below:

STANDARD PICKET SIZES

Table **20**

Nominal		(Net) Dressed	
		inch	mm
1¼" square	S4S to	1 1/16 x 1 1/16	27 x 27
1½" square	S4S to	1 5/16 x 1 5/16	33 x 33
1" x 3" flat	S4S to	¾ x 2 ½	19 x 64

Lath is available in any Western species, in two grades, NO. 1 and NO. 2, and may be shipped dry or unseasoned. Sizes are ⅜" thick by 1½" wide, 32" or 48" long.

Battens (WCLIB grade) are available in any Western species, in one grade: BATTENS. They are surfaced S1S1E or S4S at shipper's option, unless specified otherwise. Grade is based on a piece 12' long. Standard widths are shown below:

STANDARD BATTEN SIZES

Table **21**

Pattern	Nominal	(Net) Dressed	
		inch	mm
Flat	3"	¼ x 2½	6 x 64
O.G.	2"	¾ x 1¾	19 x 44
O.G.	2½"	¾ x 2¼	19 x 57
O.G.	3"	¾ x 2½	19 x 64

Stepping (WCLIB grade) is typically vertical grained (VG) and kiln dried (KD) and customarily surfaced on three sides with a bull nose on one edge. The recommended standard for STEPPING of 1¼" thickness is to round the nosed edge to a radius of ⅝". Grades are based on a piece 12" wide by 12' long. There are two grades: C&BTR-VG STEPPING and D-VG STEPPING. Refer to Paragraph 109 in WWPA *Western Lumber Grading Rules*.

SPECIFYING INDUSTRIAL LUMBER PRODUCTS

It is important to realize that not all products, grades and sizes in the industrial products category are readily available at all times. These products are rarely available through standard retail outlets as they are usually traded at the wholesale level, often as custom orders, or bought mill direct in large volumes.

WWPA's *Vol. 3 Species* book on *Factory Lumber* includes full-color photographs of the grades intended for cut up. This species brochure aids remanufacturers in determining which grades are best suited for the recovery of specifically sized pieces.

In general, industrial products are specified according to the checklist provided below:

INDUSTRIAL LUMBER MATERIAL SPECIFICATION

Checklist **7**

- ☐ Grade Description - refer to specific paragraph number in the WWPA *Western Lumber Grading Rules*
- ☐ Moisture Content - specify MC as dictated by grading rules or according to specific requirements for intended end use, realizing that "specific requirements" are available only through manufacturer/customer agreement
- ☐ Species - specify all species that are appropriate
- ☐ Profile/Surface Texture - specify when appropriate
- ☐ Sizes and Lengths - always specify all sizes and lengths that are appropriate to the application

WWPA Product Support Services may be contacted (503-224-3930) for help with industrial product specification whenever necessary.

Relative Properties of Western Species

WESTERN SPECIES DIMENSIONAL STABILITY

Wood shrinks as it seasons (dries) from the fiber saturation point (of 28% to 30% MC) to the moisture level of surrounding atmospheric conditions. Within most structures, this moisture content level is between 8% and 12%.

In one- and two-story structures, the cumulative effect of shrinkage can be accommodated on the job site, even when unseasoned lumber is specified. However, for three story and higher buildings, designs should allow for shrinkage in the horizontal members, e.g. wall plates and joists.

The shrinkage of Western species (except Western Cedars) is approximately 6% as it dries from 30% to 0% MC (4.5% for Western Cedars), i.e. 0.2% shrinkage for every 1% change in moisture content for Western species and 0.15% for Western Cedars. The shrinkage factor assumes a growth-ring angle of 45° and is an average for multiple species.

Example: To calculate the amount of shrinkage in a 2x10 lumber floor joist, manufactured at 19% (S-DRY) with an equilibrium moisture content of 8%:

9.25 inches	**x**	**0.002**	**x**	**11**	**= 0.20 inches**
width (actual width of dry 2x10)		shrinkage factor (.2% = .002)		% change in moisture content (19 – 8 = 11)	

Vertical members exhibit less dimensional change because wood's longitudinal shrinkage is quite small (approximately .003% to .0067% for every 1% change in MC).

Shrinkage factors for individual species and specific grain orientations can be found in WWPA's *Dimensional Stability-Technical Guide* (TG-3).

WEIGHT PER LINEAR FOOT

To calculate the weight per linear foot for a particular size and species, multiply the cross-sectional area of the member by the species weight and increase factors shown in Table 22. The weight factors apply to lumber at 15% MC.

WEIGHT FACTOR (15% moisture content) Table **22**

Species or Species Group	Weight Factor	Species or Species Group	Weight Factor
Douglas Fir-Larch	.233	Western Woods *(continued)*	
Douglas Fir-South	.216	Alpine Fir	.170
Hem-Fir	.203	Mountain Hemlock	.220
Spruce-Pine-Fir (South)	.171	Western Cedars	
Western Woods		Western Red Cedar	.162
Ponderosa Pine	.203	Alaskan Yellow Cedar	.220
Idaho White Pine	.194	Port Orford Cedar	.205
Sugar Pine	.184	Incense Cedar	.183

WEIGHT INCREASE FACTORS

Moisture Content	Increase Factor	Moisture Content	Increase Factor
20%	1.04	50%	1.30
30%	1.13	60%	1.39
40%	1.22	70%	1.48

Example: Weight for three feet of 2 × 8 DF-L @ 30% MC.

3	×	1.563 × 7.50	×	0.233	×	1.13	=	9.26 pounds
		actual size of unseasoned 2 × 8		weight factor for DF-L		increase factor for 30% MC		

FLAME-SPREAD RATINGS AND SMOKE-DEVELOPED INDICES

Species of wood differ in their burning rates. By measuring these rates, a standard can be established to compare different species of wood with regard to fire safety.

Flame-spread classifications have been developed by Underwriters' Laboratories, Inc. The UL Standard Test Method has established a numerical scale based on a noncombustible, asbestos-cement board as 0 (zero) and a combustible red oak as 100. The Steiner Tunnel test (ASTM E-84), conducted in a 25-foot long tunnel furnace, is used to develop the actual burning and flame-spread data. Table 23 provides flame-spread ratings and smoke-developed indices for Western softwood species, along with references to the facilities that conducted the tests.

FLAME-SPREAD RATINGS AND SMOKE-DEVELOPED INDICES: CONFORMANCE WITH MODEL BUILDING CODES Table **23**

Western Softwoods	Flame-Spread Rating	Flame-Spread Class	Smoke-Developed Index	Source
Western Larch	45	B	20	HPVA
Engelmann Spruce	55	B	35	HPVA
Hem-Fir	60	B	70	HPVA
Incense Cedar	65	B	65	HPVA
White Fir	65	B	55	HPVA
Pacific Silver Fir	69	B	58	CWC
Western Red Cedar	69	B	137	W*
West Coast Hemlock	73	B	80	W
Sitka Spruce	74	B	74	CWC
Idaho White Pine	82	C	83	W
Douglas Fir	90	C	70	W
Sugar Pine	95	C	80	HPVA
Lodgepole Pine	98	C	90	W
Ponderosa Pine	115	C	135	HPVA

W* Weyerhaeuser Fire Technology Unit, 1987, sponsored by Council of Forest Industries.
W Weyerhaeuser Fire Technology Unit, 1988.
HPVA Hardwood Plywood & Veneer Association, 1984,1995, 2000, 2001.
CWC "Wood and Fire Safety" by the Canadian Wood Council, 1991.

Model Code Requirements

The most widely accepted flame-spread classification system appears in the National Fire Protection Association Life Safety Code, NFPA 101, and the model building codes as follows:

		Example Building Locations:
0–25	flame-spread—Class A (or I)	Enclosed vertical exits
26–75	flame-spread—Class B (or II)	Exit access corridors
76–200	flame-spread—Class C (or III)	Other rooms and areas

The model building codes require a Smoke-Developed Index of 450 or less for most construction applications.

Designers should consult their model building codes for flame-spread and smoke-developed requirements for specific use, areas and occupancies. When a species does not carry a flame-spread rating appropriate to a desired application, designers may be able to use an intumescent finish or fire-retardant treatment to improve the flame-spread classification and satisfy local building codes.

Relative Properties of Western Species

SPECIFIC GRAVITY

Variations in the size of the cell cavities and pores and in the thickness of the cell walls cause some species to have more wood substance per unit volume than others, and therefore to have a higher specific gravity. Thus specific gravity provides an index to one species' density in relation to other species. The higher the number, the higher the specific gravity or density.

SPECIFIC GRAVITY OF WESTERN SOFTWOOD SPECIES Table **24**

Western Species	Specific Gravity[1] (Oven Dry Weight/ Oven Dry Volume)
Douglas Fir-Larch	0.50
Douglas Fir-South	0.46
Hem-Fir	0.43
Ponderosa Pine	0.43
Sitka Spruce	0.43
Engelmann Spruce-Lodgepole Pine	0.38
Spruce-Pine-Fir (South)	0.36
Western Cedars	0.36
Western Woods	0.36
Douglas Fir-Larch	
MSR 1.0 E to 1.9 E	0.50
MSR 2.0 E	0.51
MSR 2.1 E	0.52
MSR 2.2 E	0.53
MSR 2.3 E	0.54
MSR 2.4 E	0.55
Hem-Fir	
MSR 1.0 E to 1.5 E	0.43
MSR 1.6 E	0.44
MSR 1.7 E	0.45
MSR 1.8 E	0.46
MSR 1.8 E	0.47
MSR 2.0 E	0.48
MSR 2.1 E	0.49
MSR 2.2 E	0.50
MSR 2.3 E	0.51
MSR 2.4 E	0.52
Spruce-Pine-Fir (South)	
MSR 1.2 E to 1.7 E	0.42
MSR 1.8 E to 1.9 E	0.46
MSR 2.0 E and higher	0.50
Engelmann Spruce-Lodgepole Pine	
MSR 1.4.E and lower grades	0.38
MSR 1.5.E and higher grades	0.46

[1] **Source:** *National Design Specification for Wood Construction.*

THERMAL CONDUCTIVITY

The relatively low thermal conductivity or "k" of Western softwoods provides a significant amount of insulation. k is the amount of heat (BTUs) transferred in one hour through one square foot of material one inch thick with a difference in temperature of 1° F.

The thermal conductivity of wood increases with increased moisture content and with increased density. The k values for the Western Woods are shown in the table below.

THERMAL CONDUCTIVITY OF WESTERN SOFTWOOD SPECIES Table **25**

Species	*k*[1]	*R*/in.
Douglas Fir-Larch	.97	1.03
Douglas Fir-South	.90	1.11
Hem-Fir	.85	1.18
Western Hemlock	.92	1.09
Spruce-Pine-Fir (South)	.73	1.37
Engelmann Spruce	.72	1.40
Lodgepole Pine	.80	1.25
Sitka Spruce	.85	1.18
Western Woods	.73	1.37
Sugar Pine	.77	1.31
Ponderosa Pine	.80	1.25
Idaho White Pine	.75	1.33
Alpine Fir	.68	1.47
Mountain Hemlock	.92	1.09
Western Cedars	.73	1.37

[1] *k* values shown are for wood with 12% moisture content. For other moisture contents, there is a change in *k* of approximately .01 for each 1% moisture content difference—an increase in *k* for an increase in moisture content and a decrease in *k* for a decrease in moisture content.

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A/0709/Rev.6-08/4M