

# Designing with Lumber in the 2001 NDS<sup>®</sup>

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## Abstract

The *National Design Specification*<sup>®</sup> (*NDS*<sup>®</sup>) for Wood Construction, 2001 Edition, an ANSI national consensus standard, published by the American Forest & Paper Association's American Wood Council ([www.awc.org](http://www.awc.org)) and its supplement *Design Values for Wood Construction*, reflect changes from 1997 NDS relating to lumber design which are discussed in this paper. The 2001 NDS Supplement provides design values for structural sawn lumber and glued-laminated timber. In addition, several relevant items on lumber design values and lumber grade stamps not covered in 2001 NDS are reviewed.

## Shear Design Values for Lumber

Shear design values for lumber have been revised to reflect recent changes to ASTM Standard D 245, *Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber*. These new lumber shear design values are generally higher than earlier assigned values by a factor of 1.95.

Previous editions of the NDS allowed for increases in shear design values when various special conditions occur. Design provisions in the 2001 NDS have been revised in order to utilize the new shear design values. Notable changes to the 2001 NDS include:

- removal of the shear stress factor,  $C_H$ , for splits, checks, and shakes.
- revision of the tension-side notching equations.

- removal of the special design considerations for shear parallel to grain (horizontal shear) in bending members (4.4.2 of NDS 1997).
- revision of the shear design provisions for bending members at connections.

For more information on these changes see *Changes in the 2001 NDS for Wood Construction*, Line et. al, Wood Design Focus, Volume 12, No. 4.

## Specific Gravity Values for MSR Lumber

The majority of machine stress-rated (MSR) lumber produced is used in metal-plate connected (MPC) wood trusses, where lumber's specific gravity is a primary design parameter in sizing metal connector plates. Additionally, lumber specific gravity is a primary design parameter in designing wood connections with metal fasteners.

Lumber rules-writing agencies have provided quality control procedures for specific gravity of MSR lumber since 1992. Grading agencies have assigned specific gravity values (on oven-dry weight/oven-dry volume basis) for MSR lumber grades in Table 1, based on models relating grading machine measurements to specific gravity or qualified by test. The same approach can be used for "machine evaluated lumber" (MEL), a machine graded lumber that is similar to MSR lumber. Mills conducting daily testing for specific gravity as part of their machine graded lumber quality control program can show the specific gravity value as part of the grade stamp. Figure 1 shows examples of MSR lumber grade stamps; the bottom figure includes specific gravity of 0.47

**Table 1.**—Footnote 2 of Table 4C Design Values for Mechanically Graded Dimension Lumber from 2001 NDS Supplement.

2. SPECIFIC GRAVITY,  $G$ , SHEAR PARALLEL TO GRAIN,  $F_v$  AND COMPRESSION PERPENDICULAR TO GRAIN,  $F_{c\perp}$ . Values for specific gravity,  $G$ , shear parallel to grain,  $F_v$ , and compression perpendicular to grain,  $F_{c\perp}$ , are provided below for MSR and MEL lumber. Higher  $G$  values may be claimed when (a) specifically assigned by the rules writing agency or (b) when qualified by test, quality controlled for  $G$ , and provided for on the grade stamp. When a different  $G$  value is provided on the grade stamp, higher  $F_v$  and  $F_{c\perp}$  design values may be calculated in accordance with the grading rule requirements.

Species	Modulus of Elasticity $E$ ( $\times 10^6$ )	Specific Gravity $G$	Shear parallel to grain $F_v$	Compression perpendicular to grain $F_{c\perp}$	Grading Rules Agency
Douglas Fir - Larch	1.0 and higher	0.50	180	625	WCLIB, WWPA
	2.0	0.51	180	670	WCLIB, WWPA
	2.1	0.52	180	690	
	2.2	0.53	180	715	
	2.3	0.54	185	735	
	2.4	0.55	185	760	
Douglas Fir - Larch (North)	1.0 and higher	0.49	180	625	NLGA
Douglas Fir - South	1.0 and higher	0.46	180	520	WWPA
Engelmann Spruce-Lodgepole Pine	1.0 and higher	0.38	135	335	WWPA
	1.5 and higher	0.46	160	555	WWPA
Hem-Fir	1.0 and higher	0.43	150	405	WCLIB, WWPA
	1.6	0.44	155	510	WCLIB, WWPA
	1.7	0.45	160	535	
	1.8	0.46	160	555	
	1.9	0.47	165	580	
	2.0	0.48	170	600	
	2.1	0.49	170	625	
	2.2	0.50	175	645	
	2.3	0.51	175	670	
	2.4	0.52	180	690	
Hem-Fir (North)	1.0 and higher	0.46	145	405	
Southern Pine	1.0 and higher	0.55	175	565	SPIB
	1.8 and higher	0.57	190	805	SPIB
Spruce-Pine-Fir	1.0 and higher	0.42	135	425	NLGA
	1.8 - 1.9	0.46	160	525	NLGA
	2.0 and higher	0.50	170	615	NLGA
Spruce-Pine-Fir (South)	1.0 and higher	0.36	135	335	NELMA, NSLB, WCLIB, WWPA
	1.2 - 1.9	0.42	150	465	NELMA, NSLB
	1.2 - 1.7	0.42	150	465	WWPA
	1.8 - 1.9	0.46	160	555	
	2.0 and higher	0.50	175	645	
Western Cedars	1.0 and higher	0.36	155	425	WCLIB, WWPA
Western Woods	1.0 and higher	0.36	135	335	WCLIB, WWPA

<sup>a</sup> NELMA is North Eastern Lumber Manufacturers Association; NLGA is National Lumber Grading Association; NSLB is Northern Softwood Lumber Bureau; SPIB is Southern Pine Inspection Bureau; WCLIB is West Coast Lumber Inspection Bureau; WWPA is Western Wood Products Association.

qualified by test and daily quality control. Values indicated on the grade stamp are permitted to differ from those listed in Table 1. Figure 2 shows typical MEL grade stamps.

Tabulated specific gravity ( $G$ ) values may be used to calculate higher shear parallel to grain ( $F_v$ ) and compression perpendicular to grain ( $F_{c\perp}$ ) design values for machine graded

lumber than those used for visually graded lumber, in cases where the mills are providing quality control on specific gravity. The Equations for  $F_v$  and  $F_{c\perp}$  design values are:

U.S. species:

$$F_v \text{ (in psi)} = 40 + (266 \times G)$$

$$F_{c\perp} \text{ (in psi)} = (2252.4 \times G) - 480$$



Figure 1.—A typical MSR grade stamps. The bottom figure shows a specific gravity value.

Canadian species:

$$F_v \text{ (in psi)} = 26.6 + (284.8 \times G)$$

$$F_{c\perp} \text{ (in psi)} = (2243.8 \times G) - 473.8$$

Alternatively, specific gravity,  $F_v$  and  $F_{c\perp}$  design values have been specifically assigned to listed grades and species of machine graded lumber based on test data and property relationships. Since  $F_v$  and  $F_{c\perp}$  design values vary among lumber agencies, current design values published by grading agencies are tabulated in the *2001 NDS Supplement* as a convenience for designers (Table 1).

Assignment of specific gravity values to machine graded lumber expands choices of lumber products for users such as MPC wood truss manufacturers.

#### Design Values for Non-North American Lumber Species

Design values for non-North American lumber species are provided in Table 4F of the *2001 NDS Supplement*. The values were developed following ASTM Standards D1990, D2555, and D245. West Coast Lumber Inspection Bureau is listed as the grading rules agency for these design values. Figure 3 shows a typical grade stamp for non-North American lumber.

#### Replacing End Grain Bearing ( $F_g$ ) Values With Compression Parallel ( $F_c$ ) Values

Historically, bearing end grain design values,  $F_g$ , were greater than compression parallel to grain design values,  $F_c$ . In the *1991 NDS*,  $F_c$  values were modified based on results



Figure 2.—Typical MEL grade stamps.



Figure 3.—Typical grade stamp for non-North American lumber.

from in-grade testing of full-size specimens of dimension lumber. In many cases, these new in-grade  $F_c$  values were significantly higher than the old  $F_g$  values based on small, clear samples.

In order to achieve consistency in design of compression members, bearing end-grain design values in the *2001 NDS Supplement* were deleted and provisions in the *2001 NDS* for designing end-grain bearing were modified to use compression parallel to grain values. For dimension lumber, compression parallel to grain design values,  $F_c$ , are generally higher than bearing design values,  $F_g$ . For timbers,  $F_g$  is typically higher than  $F_c$ .

#### Timber Design Values for Western Species

Timber (5 inches and thicker) design values for western species were different between Western Wood Products Association (WWPA) and West Coast Lumber Inspection Bu-

### Procedures for the Development of Lumber Design Values

Design values for structural timbers (5 inches and thicker) and dimension lumber (2 inches to 4 inches thick) are computed in accordance with ASTM standards based on clearwood tests or on tests of full-size pieces in specific grades. 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 clearwood-based properties, and D 1990 for full-size test specimens.

The ASTM methods result in stiffness (E) values that are expected to be an average for the grades listed, while compression perpendicular to grain values are an average for the species group. Test results for other properties are statistically evaluated per ASTM standards so that the strength levels listed are expected to be exceeded by 95% of the pieces in the various grades and sizes. Standard ASTM reductions have been made to values to account for safety and duration of load.

reau (WCLIB) in 1997 *NDS* and prior editions. The differences, although small, created confusion within the design community. In the 2001 *NDS Supplement*, new design values have been assigned to WWPA timber grades to be the same as those published by WCLIB<sup>1</sup>. Accordingly, the WWPA timber grading rules have been revised.

#### New MEL Grades

New MEL grades have been added to the 2001 *NDS Supplement* including:

Designation	$F_b$ (psi)	$F_t$ (psi)	$F_c$ (psi)	E (psi)
M-30	2,050	1,050	1,850	1,700,000
M-31	2,850	1,600	2,150	1,900,000

#### Substitution of MSR Lumber Grades for Visually Graded Lumber Grades

The 2001 *NDS* design procedures, as in previous editions, recognize the lower variability in stiffness (E) for MSR lumber (Fig. 1). This is factored into calculations for beam and column stability, based on the 5th percentile E property. E values for MSR lumber should be increased by 39% when comparing with E values of visually graded lumber. This increase applies only to stability calculations of allowable structural loads for beams, columns, and studs. This increase is appropriate for calculating design load for wood studs. With this increase, design values for MSR lumber grades can be compared to those published for visual

<sup>1</sup> Modulus of elasticity (E) for Sitka Spruce No. 2 grade is still different between WWPA and WCLIB by one rounding increment (100,000 psi).

### Design Values for U.S. and Canadian Species Combinations Lumber

Lumber is produced in special cases from resources of both the U.S. and Canada — species combinations for lumber grown in both sides of the border. For example, U.S. Douglas Fir/Larch and Canadian Douglas Fir/Larch (North), U.S. Hem-Fir and Canadian Hem-Fir (North), and U.S. Spruce-Pine-Fir (South) and Canadian Spruce-Pine-Fir. The U.S. and Canadian species that are manufactured separately carry individual design values published in the 2001 *NDS Supplement*. Design values for the species combinations are the lower of the two species in each grouping for all grades of dimension lumber under the NGR. (Note: this does not change the design values assigned to these species combinations when used separately.)

Prior to the use of these species combinations, a manufacturer of dimension lumber (2×2 through 4×18) from both U.S. and Canadian logs was required to separate logs by their origins. Logs grown domestically and from Canada were milled at different times and stamped accordingly. The new species combinations eliminate the need for keeping separate the logs from north and south of the U.S.-Canadian border.

An example of these grade stamps and design values for three species combinations are provided in WWPA's website. The species combination designation for the combination of U.S. and Canadian species groups is shown together on the grade stamp.



Typical grade stamp for combinations of U.S. and Canadian species.

grades, although the increase cannot be applied directly to mean values. A detailed discussion is provided on AWC's website ([www.awc.org/technical/msr-mel.html](http://www.awc.org/technical/msr-mel.html)) and in the WCLIB publication Technical Note No. 1.

#### KD HT Lumber Grade Stamp

A new mark on gradestamped lumber has been used since early 2002. Lumber mills are now producing lumber showing a KD HT mark, indicating the wood has been kiln dried (KD) and heat-treated (HT) (Fig. 4). The KD HT mark was added to meet new European Union 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 is heated to a core temperature of 56°C for a minimum of 30 minutes.

### Finger-Jointed Lumber in Metal Plate Connected Wood Trusses

The 2001 NDS contains information about end-jointed (finger-jointed) or edge-glued lumber. The published lumber design values for solid sawn lumber are applicable to the same species and grade of structural glued lumber, as specified. A new section is provided in the Truss Plate Institute's American National Standard ANSI/TPI 1-2002 for Metal Plated Connected Wood Truss Construction recognizing the use of structural finger-jointed lumber for MPC Wood Trusses. It states that:

#### 3.4.5

*Structural finger-jointed lumber shall be permitted to be used interchangeably with solid sawn members of the same grade and species if the finger joints are manufactured with an adhesive meeting the requirements of ASTM D2559. Structural finger-jointed lumber shall be identified by the grade mark of, or certificate of inspection from, a lumber grading or inspection agency that has been approved by an accreditation body that complies with U.S. Department of Commerce (DOC) PS 20 or equivalent. The grade mark and certification of inspection for structural finger-jointed lumber shall indicate that joint integrity is subject to qualification and quality control. When finger-jointed lumber is marked "STUD USE ONLY" or "VERTICAL USE ONLY", such lumber shall not be used in metal plate connected wood trusses.*

This change confirms the acceptance of structural finger-jointed lumber in MPC wood trusses. In fact, it has been in limited practice for some time and is already recommended by some (not all) truss plate manufacturers. The new section explicitly confirms the use of finger-jointed lumber in wood trusses. It should be noted, however, that finger-jointed lumber should be handled carefully in transit and on building sites to avoid undue out-of-plane stresses.

'STUD USE ONLY' and 'VERTICAL USE ONLY' finger-jointed lumber is not intended for long-term bending and tension stresses that are common in MPC wood trusses. Adhesives used for these products are not tested for creep per ASTM D2559.



Typical grade stamp for certified finger-jointed lumber.

### Flame Spread Ratings

New flame spread ratings for additional species have been developed. The AWC publication *Design for Code Acceptance No. 1 on Flame Spread Performance of Wood Products* (DCA 1) has been revised to incorporate the new entries and is available free from AWC's website.



Figure 4.—Typical kiln dried (KD), heat treated (HT) grade stamp.

Many mills are adding the new designation to grade-marks. For structural framing applications, including MPC wood trusses, the KD HT mark can be considered the same as surfaced dry (S-DRY) and KD. The same is applicable for HT surfaced green (S-GRN) – heat treated and over 19% moisture content, unseasoned – which is equivalent to S-GRN.

### Websites

A host of lumber technical and product information is available online on the websites. For further information, contact the following agencies.

- Western Wood Products Association: [www.wwpa.org](http://www.wwpa.org), 503-224-3930, [info@wwpa.org](mailto:info@wwpa.org)
- American Wood Council: [www.awc.org](http://www.awc.org), 202-463-4713, [awcinfo@afandpa.org](mailto:awcinfo@afandpa.org)
- Canadian Wood Council: [www.cwc.ca](http://www.cwc.ca), 1-800-463-5091 (help-line)
- West Coast Lumber Inspection Bureau: [www.wclib.org](http://www.wclib.org), 503-639-0651, [info@wclib.org](mailto:info@wclib.org)
- Southern Pine Inspection Bureau: [www.spib.org](http://www.spib.org), 850-434-2611, [spib@spib.org](mailto:spib@spib.org)

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