WWPA Technical Services Division

Tech Notes

2003-01

Designing with Western Lumber in the *2001 NDS*

The National Design Specification (NDS®) for Wood Construction, 2001 Edition, an ANSI national consensus standard, and its supplement *Design Values for Wood Construction* are both published by the American Forest & Paper Association's American Wood Council, (**www.awc.org**). This new edition features changes from the *1997 NDS* relating to Western lumber design.

Revised design values for structural sawn lumber and glued-laminated timber are published in the *2001 NDS Supplement*. This *Tech Note* higlights the revisions to lumber design values. In addition, several relevant items on Western lumber design values and grade stamps not covered in the *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 the *1997 NDS*).
- 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*, at **www.awc.org/Publications/papers/NDS2001article.pdf**.

SPECIFIC GRAVITY VALUES FOR MSR LUMBER

The majority of machine stress-rated (MSR) lumber produced is used in metal-plate connected wood trusses, where lumber's specific gravity is a primary design parameter in sizing metal connector plates. Additionally, the specific gravity of lumber 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. Based on experience and other research, grading agencies have assigned specific gravity values (on oven-dry weight/oven-dry volume basis) for MSR lumber grades in Table 1, using models relating grading machine measurements to specific gravity or by qualified testing.

These specific gravity values allow more efficient truss plate design when using MSR lumber products. In addition, revisions in the *NDS* allow the interchangeable use of U.S. Spruce-Pine-Fir (SPFs) MSR lumber or Canadian SPF of the same grade and size.

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* is an example MSR lumber grade stamp showing specific gravity of 0.47 qualified by testing and daily quality control. Values indicated on the grade stamp are permitted to differ from those listed in *Table 1*.

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Table 1. Excerpted from Footnote 2 of Table 4C, Design Values for Mechanically Graded Dimension Lumber from the *Supplement of National Design Specification for Wood Construction 2001 Edition.*

SPECIFIC GRAVITY, SG, SHEAR PARALLEL TO GRAIN, F_V, AND COMPRESSION PERPENDICULAR TO GRAIN, $F_{c\perp}$. Values for specific gravity, SG, shear parallel to grain, F_V, and compression perpendicular to grain, $F_{c\perp}$, are provided below for MSR and MEL lumber. Higher SG values may be claimed when (a) specifically assigned by the rules writing agency or (b) when qualified by test, quality controlled for SG, and provided for on the grade stamp. When a different SG 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	Specific Gravity	Shear parallel to grain	Compression perpendicular to grain
	E (x10^6 psi)	SG	F_V (psi)	$F_{c\perp}$ (psi)
Douglas Fir - Larch	1.0 and higher	0.50	180	625
	2.0	0.51	180	670
	2.1	0.52	180	690
	2.2	0.53	180	715
	2.3	0.54	185	735
Douglas Fir - Larch (N)	1.0 and higher	0.49	180	625
Douglas Fir - South	1.0 and higher	0.46	180	520
Engelmann Spruce-	1.0 and higher	0.38	135	335
Lodgepole Pine	1.5 and higher	0.46	160	555
Hem-Fir	1.0 and higher	0.43	150	405
	1.6	0.44	155	510
	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
Hem-Fir (N)	1.0 and higher	0.46	145	405
Southern Pine	1.0 and higher	0.55	175	565
	1.8 and higher	0.57	190	805
Spruce-Pine-Fir	1.0 and higher	0.42	135	425
	1.8 - 1.9	0.46	160	525
	2.0 and higher	0.50	170	615
Spruce-Pine-Fir (South)	1.0 and higher	0.36	135	335
	1.2-1.7	0.42	150	465
	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
Western Woods	1.0 and higher	0.36	135	335

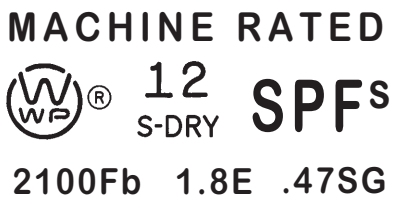

Fig. 1. Typical MSR grade stamp showing specific gravity value.

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 MSR 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 (in psi) = 40 + (266 x G)
F_c (in psi) = (2252.4 x G) – 480

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

Assignment of specific gravity values to MSR lumber should expand choices of lumber products for users such as wood truss manufacturers.

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 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 wood samples.

To achieve consistency in design of compression members, in the 2001 *NDS* bearing end-grain design values were deleted and provisions 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.

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 determined in accordance with ASTM standards based on clear wood 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 clear wood-based properties, and D 1990 for full-size test specimens.

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

An overview of the In-Grade Testing Program, which yielded new test data on the structural performance of softwood lumber, is provided in WWPA *Tech Note No. 4* available online at **www.wwpa.org/pdf/TN4.pdf**.

TIMBER DESIGN VALUES FOR WESTERN SPECIES

In the past, timber (5 inches and thicker) design values for Western species published by Western Wood Products Association (WWPA) and West Coast Lumber Inspection Bureau (WCLIB) were different, as noted in the *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 the WWPA timber grades to match those published by WCLIB[1]. Accordingly, the WWPA timber grading rules have been revised.

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

SUBSTITUTION OF MSR LUMBER GRADES FOR VISUALLY GRADED LUMBER GRADES

Current engineering design procedures, as in previous editions, recognize the lower variability in stiffness (E) for MSR lumber. 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 percent 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 grades, although the increase cannot be applied directly to the published average E values. A detailed discussion is provided online at **www.awc.org/technical/msr-mel.html**.

FLAME SPREAD RATINGS

New flame-spread ratings for additional Western species have been developed, and are provided in the WWPA publication A-4, *Flame-Spread Ratings*, which can be downloaded at **www.wwpa.org/store**.

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) (see Figure 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 was heated to a core temperature of 56°C for a minimum of 30 minutes.

Many mills are adding the new designation to grademarks. For structural framing applications, including

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:

> *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.

Fig. 2. Typical grade stamp for certified finger jointed lumber.

'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.

DESIGN VALUES FOR U.S. AND CANADIAN SPECIES COMBINATIONS LUMBER

Mills in the U.S. and Canada produce lumber in similar species name combinations. While the species may be named nearly the same, design values for like-named U.S. and Canadian species combinations are different. This means design values for U.S. Douglas Fir-Larch differ from Canadian Douglas Fir-Larch (North). There are also differences in design values between 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. (Note: this does not change the design values assigned to the species groups when used separately.)

Given the changes in available timber supply, some mills process logs that come from both countries. The species designations for the combination of U.S. and Canadian species groups are shown together on the grade stamp (see Figure 3.)

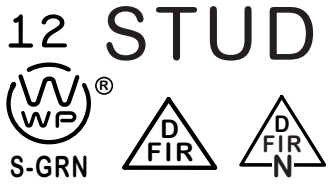

Fig. 3. Typical grade stamp for combinations of U.S. and Canadian species.

Grade stamp impressions, design values and span tables for U.S. and Canadian Douglas Fir-Larch/ Douglas Fir-Larch North, Hem-Fir/Hem-Fir North and Spruce-Pine-Fir (South)/Spruce-Pine-Fir combinations are provided in a WWPA *Tech Note* at **www.wwpa.org/pdf/TN US-Can species.pdf.** Note that lower design values and shorter spans are a typical result of mixing U.S. and Canadian species groups.

MPC wood trusses, the KD HT mark can be considered the same as surfaced dry (S-DRY) and KD. Since heat treating only partially dries the wood, lumber marked as HT can be considered an equivalent to surfaced green (S-GRN) - over 19% moisture content, unseasoned.

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