DESIGN VALUES

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30.0 INFORMATION

The following paragraphs, 31.0 to 37.0, have been adopted from WWPA. Minor modifications were made to make these paragraphs apply to the Northeast. This information is intended to assist in the proper utilization of lumber.

31.0 LUMBER DESIGN VALUES

The design values listed in these rules are for lumber of species manufactured and shipped by mills in the nine northeastern states. Except as otherwise noted, the values are computed in accordance with the American Society for Testing and Materials (ASTM) standards based upon clear wood tests or an ASTM standard based upon tests of full size pieces of specific grades. The applicable standards are ASTM D2555, D245, and D1990, published by the ASTM. Both the clear wood tests and the full size tests were performed in cooperation with the U.S. Forest Products Laboratory, Madison, Wisconsin.

The ASTM methods result in stiffness values that are expected to be an average for the grades listed. Test results for other properties are statistically evaluated by ASTM standards so that the strength levels listed herein are expected to be exceeded by 95% of the pieces in the various grades and sizes. The strength levels are also listed in the “National Design Specification for Wood Construction,” published by the American Forest and Paper Association, 1111 19th Street N.W., Suite 800, Washington, D.C. 20036. Standard ASTM reductions have been made to values to account for safety and duration of load.

STRENGTH PROPERTIES

Lumber strength values are assigned to five basic properties: fiber stress in bending (Fb), tension parallel to grain (Ft), horizontal shear (Fv), compression parallel to grain (Fc//), and compression perpendicular to grain (Fc⊥).

Fiber stress in bending values are calculated for pieces loaded on either the narrow face or on the wide face with the following exceptions:

1. Bending stress calculations for Beams and Stringers are for pieces loaded on the narrow face.
2. Bending stress calculations for Decking are for pieces loaded on the wide face.

   Bending stresses for Decking less than 4' in thickness and for Stress Rated Boards and Dimension when used flatwise may be adjusted in accordance with ASTM standards as shown in para. 34.0.

   Fiber stress in bending (Fb) values for the various grade classifications of Machine Stress Rated lumber are based on the correlation of the modulus of rupture (MOR) to (E). Machine output is controlled by testing pieces and adjusting the machines so that the minimum assigned Fb value (derived from a 5% exclusion level of MOR) is met after applying the same reduction factors for safety and duration of load as are applied to visually stress graded lumber in accordance with ASTM D245. Compression perpendicular to grain (Fc⊥) and horizontal shear (Fv) values are assigned as a function of the species clear wood values in accordance with ASTM D245.

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MODULUS OF ELASTICITY

The modulus of elasticity (E) is a ratio of the amount a material will deflect in proportion to an applied load. It is a measure of stiffness and not a strength property. It is not related to safety except in column designs where (E) values are reduced nearly three times. The tabulated (E) values are average values and individual pieces having values both above and below the listed average occur in all lumber grades. For all normal construction, use of average (E) values provides a conservative prediction of deflections which occur in wall, floor and roof assemblies. Tests by government, university and private research organizations show that deflections occurring when loads are applied are less than predicted with use of average (E) values.

Modulus of Elasticity for Machine Stress-Rated Lumber

The (E) value for Machine Stress-Rated (MSR) lumber is determined by nondestructively testing individual pieces. The (E) values shown herein and on grade stamps are average values. Machines are adjusted so that the entire output of the machines at any indicated (E) level will average to the (E) value shown on the stamp.

32.0 SINGLE MEMBER DESIGN VALUES

The bending (Fb), tension (Ft), compression parallel to grain (Fc) and modulus of elasticity (E) design values shown in Tables 1 and 2 in Section 8 have been calculated in accordance with ASTM Standard D 1990. The remaining design values in Tables 1, 2, 4 and 5 in section 8 have been calculated in accordance with ASTM Standards D 2555 and D 245. Adjustment factors shown in para. 34.0 through 36.0 are also derived from ASTM Standards.

By the use of ASTM standards, it is assumed that 95% of the pieces of lumber in each grade should possess the bending strength values tabulated for the grade times a factor of 2.1. These design values are intended for use with existing design methods. Users or specifiers who have need for more technically precise values for any particular single member design may specify Machine Stress-Rated lumber. See para. 16.0.

33.0 REPETITIVE MEMBER DESIGN VALUES

In many structures where 2" and 4" thick lumber is used, the pieces are used repetitively. Joists, Studs and Rafters are examples of uses where a number of pieces side by side share the load and the strength of the entire assembly is enhanced. This is called repetitive member use.

Where 3 or more members are adjacent or are not more than 24" apart and are joined by floor, roof or other load distributing elements, the bending values (Fb) listed in Table 1, Section 8 may be increased 15% to adjust for the load sharing influence in design. Tests have confirmed that structures designed with repetitive member values sustain loads substantially greater than required by design criteria.

34.0 EFFECT OF DEPTH ON DESIGN VALUES

ASTM standards provide means to adjust fiber stress in bending values depending on lumber sizes and how a piece of lumber is used (on edge or flatwise). For Stress-Rated Boards and Dimension 2" to 4" in thickness when used flatwise, the design values for fiber stress in bending shown in Tables 1 and 2, Section 8 may be multiplied by the factors shown in the following table:

ADJUSTMENT FACTORS FOR DIMENSION LUMBER USED FLAT

Nominal	Nominal Thickness	
Width	3" & Less	4"
2" & 3"	1.00	—
4"	1.10	1.00
5"	1.10	1.05
6" & 8"	1.15	1.05
10" & Wider	1.20	1.10

Decking bending design values may be adjusted for thickness as shown in the following table because bending values shown in para. 15.0, 15.1 and 15.2 are based on a 4” thick member loaded flatwise.

ADJUSTMENT FACTORS FOR DEPTH EFFECT

For all widths of Decking Nominal Thickness			
1”	**2”**	**3”**	**4”**
1.19	1.10	1.04	1.00

See adjustment factors for beams and stringers in para. 25.4.

35.0 EFFECT OF MOISTURE CONTENT ON DESIGN VALUES (140.00 WWPA)

The design values shown in Tables 1 and 2, Section 8 are calculated for lumber that will be used under dry conditions such as in most covered structures.The section properties of lumber for use in design should be based on the surfaced sizes shown in these rules. For 2” to 4” thick lumber the DRY surfaced size should be used. In calculating design values, the natural gain in strength and stiffness that occurs as lumber dries has been taken into consideration as well as the reduction in size that occurs when unseasoned lumber shrinks. For 5” and thicker lumber, the surfaced sizes also may be used because design values have been adjusted to compensate for any loss in size by shrinkage which may occur.

Machine Stress-Rated lumber may be produced in either the seasoned or unseasoned condition. However, design values for Machine Stress-Rated lumber are based on DRY surfaced sizes and a condition of use where moisture content will not exceed 19%.

There are two situations where the tabulated design values should be adjusted.

1. **Adjustment Factors for Nominal 2” to 4” Thick Lumber**

When 2” to 4” thick lumber is designed for exposed uses where the moisture content will exceed 19% for an extended period of time, the design values shown in Table 1 and 2, Section 8 as well as tables shown in para. 15.2 and 16.0 should be multiplied by the following adjustment factors: (Note that these factors apply to value for Dry lumber.)

Extreme Fiber in Bending	Tension Parallel to Grain	Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity
“Fb” 0.85*	“Ft” 1.00	“Fv” 0.97	“Fc⊥” 0.67	“Fc//” 0.80**	“E” 0.90

* Where the size-adjusted single member bending value does not exceed 1150 psi a factor of 1.0 may be used.

** Where the size-adjusted compression parallel to grain value does not exceed 750 psi a factor of 1.0 may be used.

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2. **Adjustment Factors for 5” and Thicker Lumber**

When lumber 5” and thicker is designed for exposed uses where the moisture content will exceed 19% for an extended period of time, the design values shown in Table 3 and 4, Section 8 should be multiplied by the following adjustment factors:

Extreme Fiber in Bending	Tension Parallel to Grain	Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity
“Fb” 1.00	“Ft” 1.00	“Fv” 1.00	“Fc⊥” 0.67	“Fc//” 0.91	“E” 1.00

36.0 NOTES ON HORIZONTAL SHEAR
(150.00 WWPA)

All horizontal shear values are assigned in accordance with ASTM Standards. A reduction is made to compensate for any degree of shake, check, or split that might develop in a piece.

37.0 NOTES ON COMPRESSION PERPENDICULAR TO GRAIN
(151.00 WWPA)

Design values for compression perpendicular to grain (Fc⊥) 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 of 0.04" and are considered adequate for most classes of structures. Where more stringent measures need be taken in design, the following formula permits the designer to adjust design values to a more conservative deformation basis of 0.02".

$$Y_{02} = 0.73Y_{04} + 5.60$$

EXAMPLE:

SPFs $Y_{04} = 335$

$Y_{02} + 0.73(335) + 5.60 = 250$Psi

38.0 EFFECT OF HOLES ON DESIGN VALUES (160.00 WWPA)

Many grades permit not firmly fixed knots or knot-holes. Holes and knots not firmly fixed do not

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reduce strength more than intergrown knots so no distinction need be made between knots and holes. For the sake of appearance, holes in certain grades are frequently restricted more severely than knots.

39.0 LOAD AND RESISTANCE FACTOR DESIGN (LRFD) (180.00 WWPA)

The design values shown in Tables 1, 2, 3, and 4, (Section 8) as well as the design values for Machine Stress-Rate Lumber (para. 16.0) and Decking, (para. 15.2, 15.3, and 15.4) are for use with Allowable Stress Design (ASD). Load and Resistance Factor Design (LRFD) is an alternative engineering method. The design values for LRFD, called reference resistance values, can be computed by multiplying the ASD design values by the conversion factors shown in the following table:

Conversion Factors for LRFD Use*

Extreme Fiber Stress in Bending "Fb"	Tension Parallel to Grain "Ft"	Horizontal Shear "Fv"	Compression Perpendicular to Grain "Fc⊥"	Compression Parallel to Grain "Fc//"	Modulus of Elasticity "E"
2.54	2.70	2.88	2.08	2.40	1.00

*These factors have been established in accordance with the procedures set forth in ASTM Standard D 5457.

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