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September 15, 2011 By EMail

Mr. John H. McDaniel
American Lumber Standard Committee
P.O. Box 210
Germantown, MD 20875-0210

RE: ALSC 10-20-11 Board of Review Agenda Item

Dear John,

The Southern Pine Inspection Bureau requests that the ALSC Board of Review approve the attached Supplement to the 2002 Grading Rules for Southern Pine Lumber. This supplement applies only to visually graded dimension lumber. Timbers, industrial, Radius Edge Decking and mechanically graded lumber (MSR/MEL) are not affected:

- Modifies the design values of the major species of Southern Pine
- Design values for minor species are lowered to the major species values
- Changes the introductory text with an explanation of visually graded lumber design values.

These proposed design values are based on testing conducted in accordance with the Board of Review approved Enhanced Resource Monitoring Program.

The attached Supplement 9 to the 2002 Standard Grading Rules for Southern Pine Lumber has been approved by the Board of Governors with the provision that five additional cells be tested in the IGT matrix. Upon completion of the six cells the design values will be adjusted and submitted to the Board of Governors and the ALSC Board of Review.

Sincerely,

Robert M. Browder
ASQ Certified Quality Engineer
Secretary, Director of Lumber

Attachments: Design Value Supplement
Design Value Proposal
Bending Data
Tension Data

APPENDIX A
Design Values for Wood

Wood is a natural product subject to variations in geography, climate, specific site characteristics, silvacultural practices, and harvesting decisions. Its' strength properties are not only anisotropic (vary by principal axis) but also can vary with proximity to the center of the tree. These characteristics complicate the assignment of individual pieces into design value groups based on the visual appearance.

American Society for Testing and Materials consensus standards D245, D2555 and D1990 are all used to assign design values for bending, tension and compression parallel to grain to visually graded lumber. The particular standard used is dependent upon the species or species grouping under consideration. Design values for horizontal shear and compression perpendicular to grain for visually graded lumber are derived using only the procedures specified in ASTM D245 and ASTM D2555. Design values for Timbers and industrial lumber are also established using only ASTM D245 and ASTM D2555. The use of D245 and D2555 results in design values which are based upon testing clear wood samples of each species or each species within a species grouping. For species groups, the strength values for each species are combined into a single value by using a weighting procedure based on standing timber volume of each species in the group. On the other hand, design values for visually graded dimension lumber for some species such as Southern pine are established using ASTM D1990. These values are based upon testing a representative sample of lumber meeting the visual requirements of the grade group under consideration. Not every grade group is tested nor is every physical property tested. Interpolations and calculations are used to provide design values for the grade groups. While the Modulus of Elasticity is represented by an average value, other properties such as bending strength and compression parallel to grain are represented by a lower 5% exclusion value. The sample data is adjusted for testing conditions, adjusted to a characteristic size and ranked by value (numerical order). The lower order value can be described as that statistical value in which there is 75% confidence that 95% of a similar sample will meet or exceed this 5^{th} percentile value. This value is then used to establish the design value.

Designers of wood structures are cautioned to take into consideration the variability of wood within a species and grade grouping. Each piece or lot of visually graded lumber is not mechanically tested to verify strength properties. Since the stress ratings are representative of the entire producing region, complete shipments from a specific location may have physical properties at the extremes of the property range or statistical distribution representing that range of strength values.

TABLE 1.A – STRUCTURAL LIGHT FRAMING, STRUCTURAL JOISTS AND PLANKS, AND STUDS - 2” TO 4” THICK (Each width has a separate set of design values)

GRADE	Extreme Fiber in Bending (psi) “F_b”	Tension Parallel To Grain (psi) “F_t”	Horizontal Shear (psi) “F_v”	Compression Perpendicular to Grain (psi) “$F_{c\perp}$”	Compression Parallel to Grain (psi) “$F_{c//}$”	Modulus of Elasticity (million psi) “E”
Kiln Dried or S-Dry, MC 15, MC 19						
APPLIES TO 2” - 4” THICK – 2” - 4” WIDE ONLY						
Select Structural	**2050**	**1250**	**175**	**565**	**1400**	**1.6**
No. 1	**1300**	**800**	**175**	**565**	**1200**	**1.5**
No. 2	**1050**	**650**	**175**	**565**	**1100**	**1.4**
No. 3 and Stud	**600**	**375**	**175**	**565**	**625**	**1.2**

TABLE 1.B – STRUCTURAL LIGHT FRAMING, STRUCTURAL JOISTS AND PLANKS, AND STUDS - 2” TO 4” THICK (Each width has a separate set of design values)

GRADE	Extreme Fiber in Bending (psi) “F_b”	Tension Parallel to Grain (psi) “F_t”	Horizontal Shear (psi) “F_v”	Compression Perpendicular To Grain (psi) “$F_{c\perp}$”	Compression Parallel to Grain (psi) “$F_{c//}$”	Modulus of Elasticity (million psi) “E”
Kiln Dried or S-Dry, MC 15, MC 19						
APPLIES TO 2” - 4” THICK – 5” - 6” WIDE ONLY						
Select Structural	**1800**	**1100**	**175**	**565**	**1350**	**1.6**
No. 1	**1150**	**700**	**175**	**565**	**1150**	**1.5**
No. 2	**925**	**575**	**175**	**565**	**1000**	**1.4**
No. 3 and Stud	**525**	**325**	**175**	**565**	**600**	**1.2**

TABLE 1.C – STRUCTURAL LIGHT FRAMING, STRUCTURAL JOISTS AND PLANKS, AND STUDS - 2” TO 4” THICK (Each width has a separate set of design values)

GRADE	Extreme Fiber in Bending (psi) “F_b”	Tension Parallel to Grain (psi) “F_t”	Horizontal Shear (psi) “F_v”	Compression Perpendicular to Grain (psi) “$F_{c\perp}$”	Compression Parallel to Grain (psi) “$F_{c//}$”	Modulus of Elasticity (million psi) “E”
Kiln Dried or S-Dry, MC 15, MC 19						
APPLIES TO 2” - 4” THICK – 8” WIDE ONLY (1)						
Select Structural	**1650**	**1000**	**175**	**565**	**1300**	**1.6**
No. 1	**1050**	**650**	**175**	**565**	**1100**	**1.5**
No. 2	**850**	**525**	**175**	**565**	**975**	**1.4**
No. 3 and Stud	**500**	**300**	**175**	**565**	**575**	**1.2**

TABLE 1.D – STRUCTURAL LIGHT FRAMING, STRUCTURAL JOISTS AND PLANKS, AND STUDS - 2" TO 4" THICK (Each width has a separate set of design values)

GRADE	Extreme Fiber in Bending (psi) "F_b"	Tension Parallel to Grain (psi) "F_t"	Horizontal Shear (psi) "F_v"	Compression Perpendicular to Grain (psi) "$F_{c\perp}$"	Compression Parallel to Grain (psi) "$F_{c//}$"	Modulus of Elasticity (million psi) "E"
Kiln Dried or S-Dry, MC 15, MC 19						
APPLIES TO 2" - 4" THICK – 10" WIDE ONLY (1)						
Select Structural	1450	875	175	565	1250	1.6
No. 1	925	575	175	565	1050	1.5
No. 2	725	450	175	565	950	1.4
No. 3 and Stud	425	275	175	565	550	1.2

TABLE 1.E – STRUCTURAL LIGHT FRAMING, STRUCTURAL JOISTS AND PLANKS, AND STUDS - 2" TO 4" THICK (Each width has a separate set of design values)

GRADE	Extreme Fiber in Bending (psi) "F_b"	Tension Parallel to Grain (psi) "F_t"	Horizontal Shear (psi) "F_v"	Compression Perpendicular to Grain (psi) "$F_{c\perp}$"	Compression Parallel to Grain (psi) "$F_{c//}$"	Modulus of Elasticity (million psi) "E"
Kiln Dried or S-Dry, MC 15, MC 19						
APPLIES TO 2" - 4" THICK – 12" WIDE ONLY (1), (2)						
Select Structural	1350	825	175	565	1200	1.6
No. 1	875	525	175	565	1050	1.5
No. 2	700	425	175	565	925	1.4
No. 3 and Stud	400	250	175	565	525	1.2

TABLE 3 – LIGHT FRAMING -- 2" TO 4" THICK

GRADE	Extreme Fiber in Bending (psi) "F_b"	Tension Parallel to Grain (psi) "F_t"	Horizontal Shear (psi) "F_v"	Compression Perpendicular to Grain (psi) "$F_{c\perp}$"	Compression Parallel to Grain (psi) "$F_{c//}$"	Modulus of Elasticity (million psi) "E"
iln Dried or S-Dry, MC 15, MC 19						
APPLIES TO 2" - 4" THICK – 2" - 4" WIDE						
Construction	800	500	175	565	1150	1.3
Standard	450	275	175	565	950	1.2
Utility *	200	125	175	565	625	1.1

***Design values apply to 4" widths only.**

TABLE 6 – MIXED SOUTHERN PINE (Virginia Pine and Pond Pine)
STRUCTURAL LIGHT FRAMING, STRUCTURAL JOISTS AND PLANKS, AND STUDS - 2” TO 4” THICK
(Each width has a separate set of design values)

GRADE	Extreme Fiber in Bending (psi) “F_b”	Tension Parallel To Grain (psi) “F_t”	Horizontal Shear (psi) “F_v”	Compression Perpendicular to Grain (psi) “$F_{c\perp}$”	Compression Parallel to Grain (psi) “$F_{c//}$”	Modulus of Elasticity (million psi) “E”
Kiln Dried or S-Dry, MC 15, MC 19						
APPLIES TO 2” - 4” THICK – 2” - 4” WIDE ONLY						
Select Structural	2050	1250	175	565	1400	1.6
No. 1	1300	800	175	565	1200	1.5
No. 2	1050	650	175	565	1100	1.4
No. 3 and Stud	600	375	175	565	625	1.2
APPLIES TO 2” - 4” THICK – 5” - 6” WIDE ONLY						
Select Structural	1800	1100	175	565	1350	1.6
No. 1	1150	700	175	565	1150	1.5
No. 2	925	575	175	565	1000	1.4
No. 3 and Stud	525	325	175	565	600	1.2
APPLIES TO 2” - 4” THICK – 8” WIDE ONLY (1)						
Select Structural	1650	1000	175	565	1300	1.6
No. 1	1050	650	175	565	1100	1.5
No. 2	850	525	175	565	975	1.4
No. 3 and Stud	500	300	175	565	575	1.2
APPLIES TO 2” - 4” THICK – 10” WIDE ONLY (1)						
Select Structural	1450	875	175	565	1250	1.6
No. 1	925	575	175	565	1050	1.5
No. 2	725	450	175	565	950	1.4
No. 3 and Stud	425	275	175	565	550	1.2
APPLIES TO 2” - 4” THICK – 12” WIDE ONLY (1), (2)						
Select Structural	1350	825	175	565	1200	1.6
No. 1	875	525	175	565	1050	1.5
No. 2	700	425	175	565	925	1.4
No. 3 and Stud	400	250	175	565	525	1.2

TABLE 7 – MIXED SOUTHERN PINE (Virginia Pine and Pond Pine) LIGHT FRAMING -- 2” TO 4” THICK

GRADE	Extreme Fiber in Bending (psi) “F_b”	Tension Parallel to Grain (psi) “F_t”	Horizontal Shear (psi) “F_v”	Compression Perpendicular to Grain (psi) “$F_{c\perp}$”	Compression Parallel to Grain (psi) “$F_{c//}$”	Modulus of Elasticity (million psi) “E”
Kiln Dried or S-Dry, MC 15, MC 19						
APPLIES TO 2” - 4” THICK – 2” - 4” WIDE						
Construction	800	500	175	565	1150	1.3
Standard	450	275	175	565	950	1.2
Utility *	200	125	175	565	625	1.1

***Design values apply to 4” widths only.**

Submission of Revised Design Values for Visually Graded Southern Pine Dimension Lumber

Based on tests of 2x4 No.2 Lumber

Southern Pine Inspection Bureau
September 2011 (revised October 2011)

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Introduction

In 2010, the Southern Pine Inspection Bureau and Timber Products Inspection agreed to work collaboratively in performing bending and tension strength tests on a representative sample of #2 2x4 Southern Pine Lumber. This report summarizes the sampling, testing, data analysis and conclusions reached from this study. Further information is still needed to complete a full "testing matrix" and additional testing is planned to be completed in a timely manner.

Based on the results of testing this sample of 2x4 lumber, SPIB proposes to adjust the design values for dimension sizes of visually graded Southern Pine lumber. Further testing is underway to confirm adjustments being made to sizes and grades of lumber not tested in 2010.

Background

In 1991, the Southern Pine Inspection Bureau published design values for dimension lumber based on the newly approved ASTM D1990 Standard, "Establishing Allowable Properties for Visually-Graded Dimension lumber from In-Grade Tests of Full-Size Specimens" (ASTM International, 2007). Section 13 of this standard requires reassessment of the design values if there is "cause to believe there has been a significant change in the raw material resource or product mix." Since 1994, SPIB has participated in an annual resource monitoring program which included stiffness testing on the size-grade combination most likely to see a change in design values. This monitoring program was established with the assistance of the Forest Products Laboratory (Kretschmann, Evans, & Brown, 1999) and included obtaining a transverse vibration E value on approximately 400 pieces of Southern Pine #2 2x4, representative of the entire Southern Pine producing region.

Over the seventeen years that this monitoring program was in place, overall trends began to develop. While there was never a large enough decrease in the measured Modulus of Elasticity (E) to warrant additional testing, it was evident that a shift was occurring in the resource mix. The proportion of the material that could be classified as "dense" was originally a majority of the pieces sampled. Over time, that proportion shifted such that a majority of the samples tested no longer met the requirements to be classified as dense. Additionally, other independent tests of full-size dimension lumber indicated that it may be worthwhile to perform additional strength tests.

1.0 Sample Description

A sampling and testing plan was submitted to the ALSC Board of Review and approved in the fall of 2010. This testing plan focused on No.2 2x4's, as this is the most widely produced size/grade combination and is believed to be the most sensitive to changes in the resource. This sampling plan mimicked that used for the original In-Grade testing program. Southern Pine was sampled as a single species and includes the species: longleaf pine (*P. palustris*), shortleaf pine (*P. echinata*), loblolly pine (*P. taeda*) and slash pine (*P. elliottii*). ASTM D1990, Section 8.1 stipulates that methods for sampling shall be in accordance with ASTM D2915 (ASTM International, 2010). The goal of the sampling procedure is to obtain lumber that is representative of the total Southern Pine lumber population. The sampling procedure is described in detail in "Sampling Procedures used in the In-Grade Lumber Testing Program" (Jones, 1988). He outlines the following steps:

1. Divide the entire production area for each commercial species group into homogeneous geographic regions based on topography, climate, and known growth patterns, so that any material sampled in a region can be assumed to be representative of the region.
2. Calculate the number of pieces to be sampled in each region in proportion to the production volume of dimension lumber.
3. Establish a list of sawmills in each region for random sampling.
4. At each mill, select at least ten pieces, but no more than twenty pieces (per test cell) from any one mill. No pieces within the top layer of the bundle were selected, and each piece was judged to be on-grade by SPIB and TP Quality Supervisors.

A sample size of 360 pieces per cell (size-grade-property combination) was targeted in this testing plan as well as the original In-Grade test program.

2.0 Data Collection

All tests were performed in accordance with ASTM D4761 (ASTM International, 2011). Edge E and bending strength (MOR) tests were performed on a Metriguard 312 bending machine. Tension strength (UTS) tests were performed on a Metriguard 403 tension test machine.

The following data were collected:

1. Agency, mill, size
2. Visual grade (gradestamped on the piece as determined by the quality supervisor)
3. Piece number
4. Grade controlling characteristic
5. Maximum strength-reducing characteristic (identified by quality supervisor)
6. Rate of growth (rings per inch)
7. Percentage of summerwood
8. Presence or absence of pith
9. Size of splits
10. Thickness and width (using calipers to the nearest 0.01 to 0.03 inch)
11. Moisture content (using 2-pin resistance moisture meter)

12. Temperature
13. Code describing failure characteristics
14. Strength properties (modulus of rupture or ultimate tensile strength)
15. Modulus of Elasticity (in edgewise bending)

Modulus of rupture (MOR) and modulus of elasticity (MOE) were determined using third point loading with deflection measured at the center point. For the specimens loaded to failure in bending, load measurements were taken between 0.100" and 0.200" of deflection and used to calculate MOE. For specimens loaded to failure in tension, MOE was calculated by measuring deflection at various load levels: 200 lbs, 250 lbs, 300 lbs, 350 lbs, 400 lbs and 450 lbs. MOE calculations used the change in deflection between 200 lbs and 450 lbs of applied load. The equation to calculate MOE with third point loading and centerpoint deflection is as follows:

$$E = \frac{23 * P * L^3}{1296 * \Delta * I}$$

3.0 Data Summary

The summarizing statistics include the sample size, mean, median, nonparametric point estimates and tolerance limits, and 75% confidence intervals on the point estimate. The tolerance limit in this document refers to the tolerance limit with 95% content and 75% confidence. The point estimate is an estimate of the fifth percentile. All data have been adjusted to 15% moisture content and 73^0F.

3.1 Assessment of Grade Quality Index

ASTM D1990, Section 8.2 requires that the grade quality index of the sampled material be assessed in relation to the assumed grade quality index used to establish the matrix. The observed grade quality index for pieces that failed during testing was calculated for all pieces that did not fail in clear wood. These GQI's were ranked and the fifth percentile GQI was used as an estimate of the assumed minimum GQI for the grade. If the observed GQI is within five percentage points of the assumed minimum GQI for the grade, the sample is considered representative. If the observed fifth percentile GQI exceeds the GQI assumed for the grade by more than 5 percentage points, a reduction in characteristic value is required. ASTM D1990 does not provide guidance if the observed GQI is lower than the assumed minimum GQI. The assumed minimum GQI for No.2 is 45%.

Figure 1. Grade Quality Index Summary

Southern Pine No.2 2x4		
	Sample Size	Observed GQI
Bending	283	32%
Tension	360	45%

While the bending sample has a GQI lower than five points less than the assumed minimum for No.2, the effect would tend to be conservative in nature. Furthermore, the strength of the pieces with the lowest strength ratios were not necessarily the lowest strength values and the pieces with the lowest strength values were not necessarily the pieces with the lowest strength ratios. No increase in characteristic value to account for the lowest observed GQI is proposed. The observed GQI of the tension sample is equal to that associated with No.2.

3.2 Adjustments to Standardized Conditions

Strength properties can vary with the moisture content and temperature of the piece. Therefore, to treat each piece equitably, strength values were adjusted to certain standardized conditions. Both ambient air and wood temperatures, as well as wood moisture content, were recorded just prior to testing. Wood moisture content was determined using a 2-pin DC resistance moisture meter specifically calibrated for Southern Pine. Temperature adjustments were made to the moisture content readings (Garrahan, 1989).

3.2.1 Temperature adjustments

Strength values may be adjusted for temperature (Barrett, Green, & Evans, 1989). These adjustments vary with the moisture content, grade and property. For all properties and grades of Southern Pine, there is no adjustment for temperatures greater than 46°F. The temperatures for the bending and tension tests of Southern Pine lumber ranged from 47°F to 84°F. Therefore, no adjustments to the strength values for temperature were required.

3.2.2 Moisture Content Adjustments

Moisture content adjustments were performed in accordance with Annex A1 of ASTM D1990. For lower levels of strength property, no adjustment is made for moisture content. For strength levels greater than the specified limits, the equations are as follows:

For MOR > 2415 psi:

$$MOR_2 = MOR_1 + \frac{(MOR_1 - 2415)}{(40 - MC_1)} * (MC_1 - MC_2) \qquad (1)$$

For UTS > 3150 psi:

$$UTS_2 = UTS_1 + \frac{(UTS_1 - 3150)}{(80 - MC_1)} * (MC_1 - MC_2) \qquad (2)$$

All values of MOE are adjusted for moisture content as follows:

$$MOE_2 = MOE_1 * \frac{1.857-(0.0237*MC_2)}{1.857-(0.0237*MC_1)} \tag{3}$$

Subscripts 1 and 2 denote the conditions at original and adjusted moisture content levels, respectively. The recommended moisture content range for these equations is 10% to 23%. Values recorded less than 8% MC were adjusted from 8% to 15%. Values greater than 8% were adjusted from the actual moisture content to 15%.

Example: Adjustment for moisture content

Given: No. 2 2x4, tested at 19% MC to have an MOR of 2520 psi

Find: The new MOR, when adjusted to 15% MC

Solution: Using Equation (1):

$$MOR_2 = 2520 + \frac{(2520-2415)}{(40-19)} * (19-15) \tag{5}$$

$$MOR_2 = 2540\, psi \tag{6}$$

3.2.3 Adjustment of E for loading method

The edgewise E values were determined using a 17:1 span to depth ratio with third point loading and deflection measured at mid-span. The design values for E are published assuming a 21:1 span to depth ratio and uniform load with deflection measured at mid-span. To convert the apparent modulus of elasticity from one loading configuration to another, the K factors from ASTM D2915 (ASTM International, 2010), Table 4, are used in the following equation:

$$E_{ai2} = \frac{1+K_1\left(\frac{h_1}{L_1}\right)^2\left(\frac{E}{G}\right)}{1+K_2\left(\frac{h_2}{L_2}\right)^2\left(\frac{E}{G}\right)} * E_{ai} \tag{7}$$

Where K_1 = 0.939 for a concentrated load applied at third point, midspan deflection

K_2 = 0.960 for a uniform load, midspan deflection

h = depth of beam

L = span length

E = shear free modulus of elasticity

G = modulus of rigidity

E/G is assumed to be 16 for lumber

$$E_{ai2} = \frac{1+0.939\left(\frac{1}{17}\right)^2(16)}{1+0.960\left(\frac{1}{21}\right)^2(16)} * E_{ai} \qquad (8)$$

$$E_{ai2} = 1.01658 * E_{ai} \qquad (9)$$

3.3 Description of Statistical Methods

The mean and standard deviation were obtained using Microsoft EXCEL. The order statistics for the nonparametric estimates for the median, fifth percentile point estimates, confidence intervals and tolerance limits were obtained using a computer program developed by the US Forest Products Laboratory (Evans, Kretschmann, Herian, & Green, 2001).

4.0 Size Adjustments

4.1 Adjusting Dimensions for Moisture Content

There are two potential adjustments related to the size of the member tested. The first adjustment accounts for the shrinkage or swelling in dimensions due to changes in moisture content. Appendix X1 in ASTM D1990 provides an equation to adjust specimen dimensions to a moisture content of 15%. ASTM D1990, Section 8.4.2 states that standard dressed sizes may be used if, after applying the Appendix X1 adjustment, the specimen dimensions are within ± 1/16 inch of the standard dressed thickness and ± ¼ inch of standard dressed width. The measured width values were within this tolerance, so for further size adjustments, the standard dressed width was used. A few pieces had thickness values that exceeded the thickness tolerance, but thickness is not used for other size adjustments.

4.2 Adjusting Data to the Characteristic Size

The second size adjustment accounts for observed differences in test properties due to the size of the member tested. In accordance with ASTM D1990, the 2x4 data were adjusted to the "characteristic size". The equation for adjusting various properties from one size to a second size is found in ASTM D1990, Section 8.4.3 and is shown here as Equation (10). The subscripts 1 and 2 denote conditions at the original size and the new size respectively. The exponents vary with property and are listed below:

$$F_2 = F_1 * \left(\frac{W_1}{W_2}\right)^w * \left(\frac{L_1}{L_2}\right)^l * \left(\frac{T_1}{T_2}\right)^t \qquad (10)$$

Figure 2. Exponents for Size Adjustment Equations

Property	w	l	t
MOR, UTS	0.29	0.14	0
UCS	0.13	0	0
MOE	0	0	0

The characteristic size to which all data is adjusted is a nominal 2x8, 12' long. Therefore, when adjusting data to the characteristic size, W_2 = 7.25", and L_2 = 144". The original size of the 2x4 lumber is W_1 = 3.5" and L_1 = 60". The 60 inch test span for 2x4 corresponds to a 17:1 span to depth ratio.

Example: Adjustment for Size

Given: No.2 2x4, MOR = 2490 psi

Find: MOR value when converted to Characteristic Size.

Solution: Using Equation (10):

$$MOR_2 = 2490 * \left(\frac{3.5}{7.25}\right)^{0.29} * \left(\frac{60}{144}\right)^{0.14} \qquad (11)$$

$$MOR_2 = 1784\, psi \qquad (12)$$

All data were adjusted from the tested size and test span to the characteristic size. Table 1 summarizes the test data after adjustment to the characteristic size.

4.3 Converting to Allowable Design Values

After obtaining the No.2 Characteristic values, the size model was used again to determine a corresponding design value for No.2 2x4. Design values for 2x4, 2x6 and 2x8 are published at a 12' length, so the only further adjustment is from the 2x8 width to the 2x4 width, and the reduction by 2.1 for the factor of safety and adjustment to a ten-year duration of load:

$$MOR_2 = 1784 * \left(\frac{7.25}{3.5}\right)^{0.29} \qquad (13)$$

$$MOR_2 = 2203\, psi \qquad (14)$$

$$F_b = \frac{2203}{2.1}\, psi \qquad (15)$$

$$F_b = 1049\, psi \qquad (16)$$

This 2x4 F_b is rounded to 1050 psi. This represents a significant reduction (30%) from the currently published 2x4 value of 1500 psi. Results converted to 2x4 No. 2 allowable design values compared to currently published values are shown in Figure 3.

Figure 3. Proposed No.2 2x4 Design Values Compared to Current Design Values

	F_b, psi		F_t, psi		E, million psi	
	Current	Proposed	Current	Proposed	Current	Proposed
No. 2 2x4	1500	1050	825	650	1.6	1.4

While SPIB and TP only tested No.2 2x4, this reduction is likely not an isolated case. It is distinctly possible that other grades and other sizes of Southern Pine lumber have experienced similar reductions due to the changes in the resource. As an interim measure, SPIB proposes making the most accurate assumptions possible regarding the ASTM D1990 grade model and following the ASTM D1990 size model to establish design values for all sizes and grades of NGR visually graded Southern Pine lumber. Also, additional testing to collect data in the remaining full matrix of size/grade combinations will be expedited.

5.0 Applying the Grade Model

The ASTM D1990 grade model uses a minimum of two grades (i.e. No.2 and Select Structural) and relates the data for those cells to values for untested cells by way of the grade quality index associated with each grade. For National Grading Rule grades of visually graded lumber, the GQI is the strength ratio associated with the grade, as shown in Figure 4.

Figure 4. Bending Strength Ratios associated with visual grades

Grade	Strength Ratio
SS	0.65
No.1	0.55
No. 2	0.45
No.3 & Stud	0.26
Construction	0.34
Standard	0.19
Utility	0.09

These same strength ratios are also used for tension. From the original IGT testing, the grade model is “anchored” by the SS and No.2 characteristic values. A value of zero strength is assumed for a strength ratio of zero, and the strength values for grades lower than No.2 are interpolated. As a conservative measure, the strength value for the No.1 grade is only taken as 85% of the interpolated value between SS and No.2 for bending and tension. The following figure shows the values interpolated for the untested grades:

Figure 5. Original IGT Characteristic Values for Bending and Tension

Grade	Strength Ratio	Original IGT Characteristic Value (MOR)	Original Value from Grade Model (MOR)	Original IGT Characteristic Value (UTS)	Original Value from Grade Model (UTS)
SS	0.65	4917		2698	
No.1	0.55		3721[1]		2055[1]
No. 2	0.45	2524		1412	
No.3 & Stud	0.26		1458		816
Construction	0.34		1907		1067
Standard	0.19		1066		596
Utility	0.09		505		282

[1]Must be multiplied by 0.85 after interpolating.

Because no SS 2x4's were tested in this current testing program, a characteristic value for SS must be assumed in order to apply the grade model. The ratio of the new No.2 value to the IGT No.2 value was applied to the old SS value to obtain a proposed SS anchor point, as shown in Figure 6 for bending and in Figure 8 for tension:

Figure 6. Development of Characteristic Values for visual grades of Southern Pine in Bending

Grade	Strength Ratio	Original IGT Characteristic Value (MOR)	Current Characteristic Value	Proposed Value for SS anchor point	Proposed Char. Values for all grades
SS	0.65	4917		3475[1]	3475
No.1	0.55				2235[2]
No. 2	0.45	2524	1784		1784
No.3 & Stud	0.26				1031
Construction	0.34				1348
Standard	0.19				753
Utility	0.09				357

[1]Assumes SS is (1784/2524) = 70.7% of Original IGT SS Value.

[2] Already multiplied by 0.85 after interpolating.

Figure 7. A graphical representation of the grade model for MOR

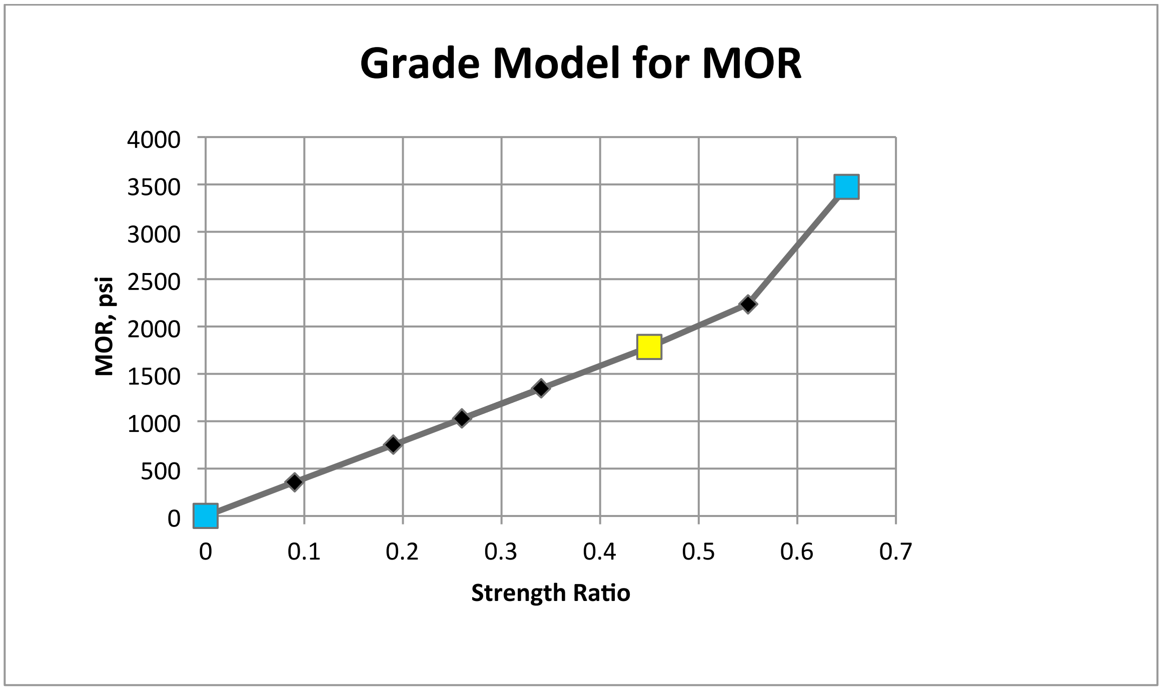


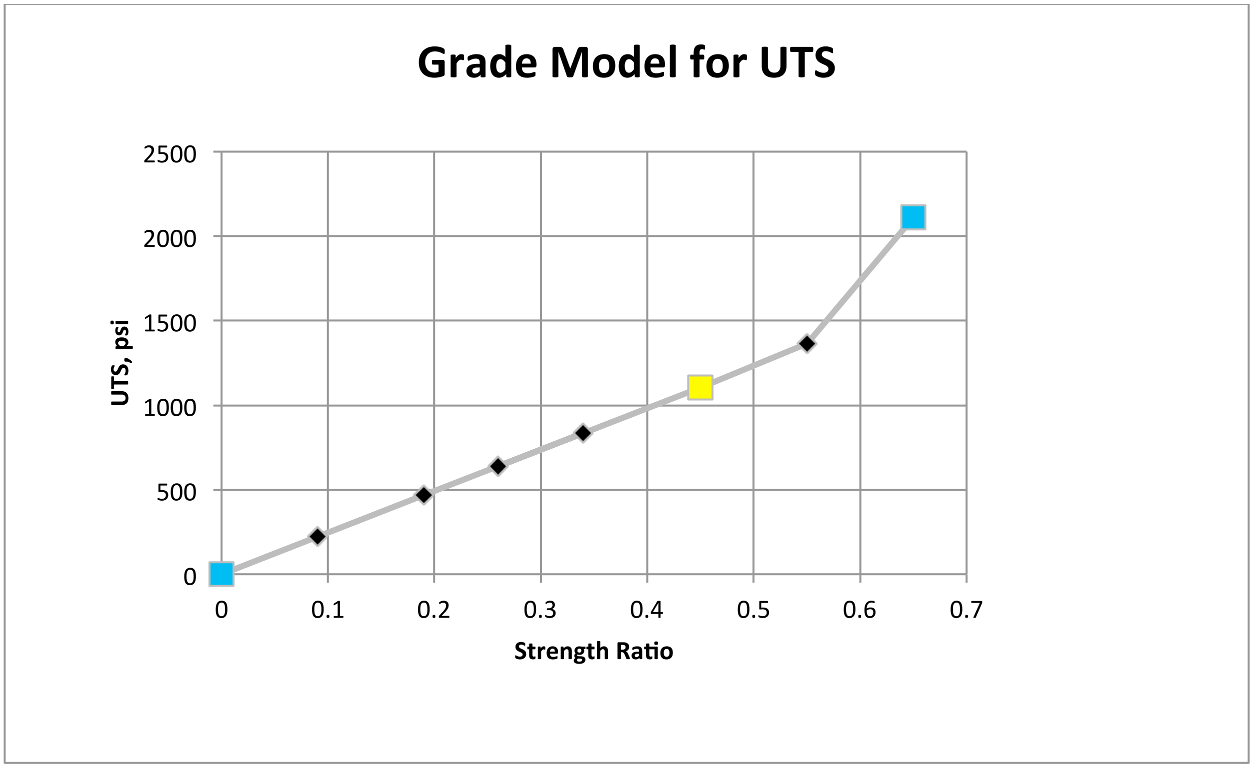
Figure 8. Development of Characteristic Values for visual grades of Southern Pine in Tension

Grade	Strength Ratio	Original IGT Characteristic Value (UTS)	Current Characteristic Value	Proposed Value for SS anchor point	Proposed Char. Values for all grades
SS	0.65	2698		2111[1]	2111
No.1	0.55				1367[2]
No. 2	0.45	1412	1105		1105
No.3 & Stud	0.26				638
Construction	0.34				835
Standard	0.19				467
Utility	0.09				221

[1]Assumes SS is (1105/1412) = 78.3% of Original IGT SS Value.

[2] Already multiplied by 0.85 after interpolating.

Figure 9. A Graphical representation of the grade model for tension



For stiffness, the grade model varies slightly in that the lower anchor point is not at zero, but rather a stiffness of (0.8*No.2) is assumed at a strength ratio of 0.09. Furthermore, the full interpolated value applies for No.1.

Figure 10. Original IGT Characteristic Values for MOE

Grade	Strength Ratio	Original IGT Characteristic Value (MOE)	Original Value from Grade Model (MOE)
SS	0.65	1.835	
No.1	0.55		1.699[1]
No. 2	0.45	1.563	
No.3 & Stud	0.26		1.398
Construction	0.34		1.467
Standard	0.19		1.337
Utility	0.09		1.250

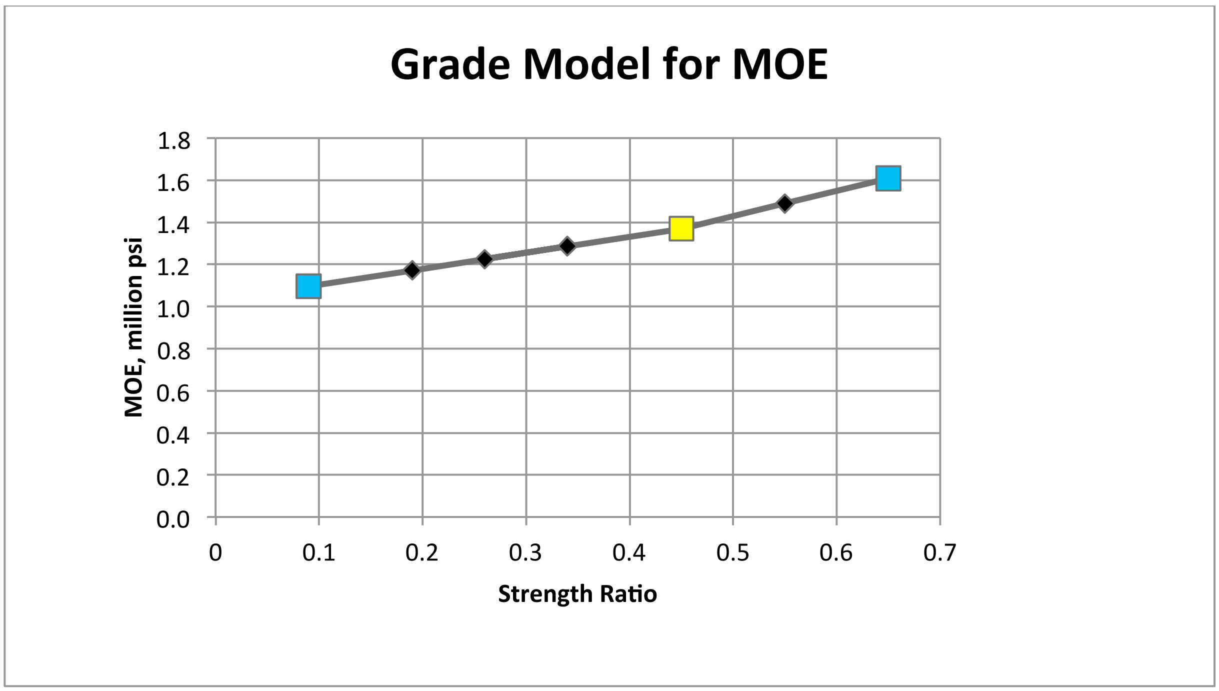
[1] For No.1, 100% of the interpolated stiffness value applies.

Figure 11. Development of Characteristic Values for visual grades of Southern Pine for MOE

Grade	Strength Ratio	Original IGT Characteristic Value (MOE)	Current Characteristic Value	Proposed Value for SS anchor point	Proposed Char. Values for all grades
SS	0.65	1.835		1.608[1]	1.608
No.1	0.55				1.489
No. 2	0.45	1.563	1.370		1.370
No.3 & Stud	0.26				1.225
Construction	0.34				1.286
Standard	0.19				1.172
Utility	0.09				1.096

[1]Assumes SS is (1.370/1.563) = 87.7% of Original IGT SS Value.

Figure 12. A Graphical representation of the grade model for MOE



6.0 Untested Properties

6.1 Compression Strength Parallel to Grain

In the limited testing conducted on the 2x4's, ultimate compression strength parallel to grain (UCS) testing was not performed. ASTM D1990, Section 9.5.2.2 permits UCS characteristic values to be estimated from the MOR characteristic values as follows:

$$C = R * \left[1.55 - \left(0.32 * \frac{R}{1000}\right) + \left(0.022 * \left(\frac{R}{1000}\right)^2\right)\right] \quad (17)$$

Valid when R is less than 7200 psi.

Using this equation, we can obtain SS and No.2 UCS values from the MOR values, as shown in Figure 13.

Figure 13. Estimating Compression Parallel Characteristic Values from Bending results

Grade	Strength Ratio	Original IGT Characteristic Value (MOR)	Proposed UCS Characteristic Value	Proposed Value from Grade Model (UCS)
SS	0.69	3475	2445	2445
No.1	0.62			2099[1]
No. 2	0.52	1784	1872	1872
No.3 & Stud	0.30			1080
Construction	0.56			2016
Standard	0.46			1656
Utility	0.30			1080

[1]Must be multiplied by 0.95 after interpolating.

Note also that the strength ratios associated with the various grades for compression are somewhat different than those used for bending and tension. Table 2 shows the assumed characteristic values for all visual grades of Southern Pine for E, MOR, UTS and UCS. Table 3 converts these characteristic values to size-specific property estimates given at a 12' length.

6.2 Compression Perpendicular to Grain

Compression perpendicular to grain strength is not addressed by ASTM D1990. Procedures defined in ASTM D2555 (ASTM International, 2000) and D245 (ASTM International, 2006) were used to assign the compression perpendicular to grain design values ($F_{c\perp}$) when the original in-grade values were published in 1991. SPIB Grading Rules (Southern Pine Inspection Bureau, 2002), Section 601.1 provides an equation to calculate $F_{c\perp}$ based on the specific gravity of the species involved. This equation is intended to be used for machine graded lumber when a grade is qualified by test and quality controlled for specific gravity. The equation is as follows:

$$F_{c\perp} = (2252.4 * SG) - 480 \quad (18)$$

The specific gravity of each bending and tension sample was calculated by obtaining the weight of each piece and using the measured dimensions. This specific gravity value was then adjusted to an oven-dry weight and oven-dry volume basis, using equations from ASTM D2395 (ASTM International, 2007). While the currently assigned specific gravity for Southern Pine is 0.55, the average observed for the 819 No.2 2x4's was 0.517 (oven-dry weight and volume basis), no change is proposed at the present time for Southern Pine specific gravity. Rather, additional data is being collected on other sizes and grades, which will provide a fuller picture of the average specific gravity.

The $F_{c\perp}$ published for unclassified visual grades of Southern Pine is 565 psi. If the observed specific gravity of 0.517 is used in the above equation, an $F_{c\perp}$ value of 684 psi obtained. In light of the fact that no mill-specific quality control is required for Southern Pine lumber specific gravity, SPIB does not propose increasing the $F_{c\perp}$ design value. Rather, $F_{c\perp}$ should remain at 565 psi.

6.3 Horizontal Shear

Horizontal shear strength is also not addressed by ASTM D1990. Procedures defined in ASTM D2555 and D245 were used to assign the horizontal shear design values (F_v) when the original in-grade values were published in 1991. SPIB Grading Rules (Southern Pine Inspection Bureau, 2002), Section 601.2 provides an equation to calculate F_v based on the specific gravity of the species involved. This equation is intended to be used for machine graded lumber when a grade is qualified by test and quality controlled for specific gravity. The equation is as follows:

$$F_v = (266 * SG) + 40 \qquad (19)$$

The F_v published for unclassified visual grades of Southern Pine is 175 psi. If the observed specific gravity of 0.517 is used in the above equation, an F_v value of 178 psi is obtained. In light of the fact that no mill-specific quality control is required for Southern Pine lumber specific gravity, SPIB does not propose increasing the F_v design value. Rather, F_v should remain at 175 psi.

7.0 Mixed Southern Pine

In the current SPIB Grading Rules, separate design values were assigned to a species grouping of "Mixed Southern Pine". This grouping included pond pine and Virginia pine, as well as any of the four major Southern Pine species. These minor species of pine were sampled at a lesser rate in the original in-grade testing program. The design values for this mixed classification were somewhat lower than those assigned to the major species of Southern Pine. In the current study of 2x4 No.2, no mixed southern pine was sampled. But based on the reductions observed for the major species, SPIB is proposing that the design values for mixed southern pine be set no higher than those being assigned for the major species of Southern Pine. A large proportion of lumber labeled “Mixed Southern Pine” is of the major species which are now known to have lower design values.

8.0 Dense Classifications for Southern Pine

When the original in-grade testing was used to develop design values, enough data existed to sort out those pieces that met the grading rule definition of “dense” lumber. Increase factors were calculated by comparing property estimates for the dense subsets to those of the unclassified data. Likewise, what was left over after the dense material was sorted out was, understandably, lower in strength than the unclassified data and reduction factors for nondense material were applied. At this point in time, there is not enough data to justify publishing separate design values for lumber visually graded as dense. Therefore, at least until more data can be collected, dense lumber will carry the same design values as the unclassified grades.

9.0 Allowable Design Values

Proposed allowable design values for Southern Pine and Mixed Southern Pine are shown in Table 4. The length associated with 2x4, 2x6, and 2x8 design values is 12’. The length associated with 2x10 and 2x12 values is 20’.

Table 1. Summarized Test Data

All Values Given at 15% MC, 73°F
Converted to Characteristic Size – 2x8 – 144”
MOE given in 10^6 psi
MOR, UTS given in psi.

	MOE	MOR	UTS
Sample Size	813	409	410
Mean	1.370	4190	2640
Median	1.319	3687	2254
5% Tolerance Limit	0.778	1784	1105

Table 2. Summary of Characteristic Values

All Values Given at 15% MC, 73°F
Characteristic Size – 2x8 – 144”
MOE given in 10^6 psi
MOR, UTS, UCS given in psi.

Grade	Strength Ratio	Mean MOE	5%TL MOR	5%TL UTS	Compr. Strength Ratio	5% TL UCS
SS	0.65	1.608	3475	2111	0.69	2445
No.1	0.55	1.489	2235	1367	0.62	2099
No.2	0.45	1.370	1784	1105	0.52	1872
No.3 & Stud	0.26	1.225	1031	638	0.30	1080
Construction	0.34	1.286	1348	835	0.56	2016
Standard	0.19	1.172	753	467	0.46	1656
Utility	0.09	1.096	357	221	0.30	1080

Table 3. Property Estimates

All Values Given at 15% MC, 73°F
Length at Characteristic Size –12'
MOE given in 10^6 psi
MOR, UTS, UCS given in psi.

Grade	Size	Tolerance Limits			Mean MOE
		MOR	UTS	UCS	
SS	2x4	4292	2607	2688	1.6
	2x6	3765	2287	2534	1.6
	2x8	3475	2111	2445	1.6
	2x10	3238	1967	2369	1.6
	2x12	3059	1858	2309	1.6
No.1	2x4	2761	1688	2307	1.5
	2x6	2421	1481	2176	1.5
	2x8	2235	1367	2099	1.5
	2x10	2083	1274	2034	1.5
	2x12	1968	1203	1982	1.5
No.2	2x4	2204	1365	2058	1.4
	2x6	1933	1197	1940	1.4
	2x8	1784	1105	1872	1.4
	2x10	1662	1030	1814	1.4
	2x12	1571	973	1768	1.4
No.3	2x4	1273	788	1187	1.2
	2x6	1117	691	1119	1.2
	2x8	1031	638	1080	1.2
	2x10	961	594	1046	1.2
	2x12	908	562	1020	1.2
Construction	2x4	1665	1031	2216	1.3
Standard	2x4	930	577	1820	1.2
Utility	2x4	441	273	1187	1.1

Table 4. Southern Pine and Mixed Southern Pine Design Values

MOE given in 10^6 psi
MOR, UTS, UCS given in psi.

Grade	Size	F_b	F_t	F_v	$F_{c\perp}$	$F_{c//}$	E
SS	2x4	2050	1250	175	565	1400	1.6
	2x6	1800	1100	175	565	1350	1.6
	2x8	1650	1000	175	565	1300	1.6
	2x10	1450	875	175	565	1250	1.6
	2x12	1350	825	175	565	1200	1.6
No.1	2x4	1300	800	175	565	1200	1.5
	2x6	1150	700	175	565	1150	1.5
	2x8	1050	650	175	565	1100	1.5
	2x10	925	575	175	565	1050	1.5
	2x12	875	525	175	565	1050	1.5
No.2	2x4	1050	650	175	565	1100	1.4
	2x6	925	575	175	565	1000	1.4
	2x8	850	525	175	565	975	1.4
	2x10	725	450	175	565	950	1.4
	2x12	700	425	175	565	925	1.4
No.3 & Stud	2x4	600	375	175	565	625	1.2
	2x6	525	325	175	565	600	1.2
	2x8	500	300	175	565	575	1.2
	2x10	425	275	175	565	550	1.2
	2x12	400	250	175	565	525	1.2
Construction	2x4	800	500	175	565	1150	1.3
Standard	2x4	450	275	175	565	950	1.2
Utility	2x4	200	125	175	565	625	1.1

(1) For Construction, Standard, and Utility grades, the F_b, F_t, and $F_{c//}$ values apply to 4" widths only.

(2) For 4" thick material that is 8" or greater in width, the F_b value may be multiplied by 1.1.

(3) For sizes wider than 12", use 90% of the F_b, F_t, and $F_{c//}$ specified for the 12" width. Use 100% of the F_v, $F_{c\perp}$, and MOE specified for the 12" width.

(4) In construction where three or more load-carrying members such as joists, rafters, studs or decking are contiguous or are spaced not more than 24 inches in frame construction and are joined by transverse floor, roof or other load distributing elements, an increase in bending stress of 15% for members used in such systems is allowed as a design consideration, as provided in ASTM D1990.

(5) For flat wise use, the following adjustments apply to F_b:

Nominal Thickness		2” & 3”	4”
Width	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

(6) The allowable unit stresses and adjustments thereof apply to lumber used under conditions continuously dry, as in most covered structures.

(7) Lumber 2-1/2” – 4” nominal thickness above 19% (S-GRN) and lumber in service under wet conditions of use or where the moisture content is at or above the fiber saturation point, as when continuously submerged, the recommended design values shall be multiplied by the following factors:

Property	Factor
$F_b \leq 1500$ psi	1.0
$F_b > 1500$ psi	0.85
F_t	1.0
F_v	0.93
$F_{c\perp}$	0.67
$F_{c//} \leq 750$ psi	1.0
$F_{c//} > 750$ psi	0.8
MOE	0.9

(8) Lumber chemically treated may require adjustments to the recommended design values. Reference should be made to the American Wood Preservers’ Association and the National Design Specification of the American Wood Council.

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Board of Review

American Lumber Standard Committee, Incorporated

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VIA E-MAIL

September 15, 2011

Mr. David Kretschmann
Dr. James Evans
Forest Products Laboratory
One Gifford Pinchot Drive
Madison, WI 53726-2398

Dear David and James,

SPIB has submitted the results of its sampling and testing information to the Board of Review. Note that these data sets have minor changes from those previously furnished to you by SPIB.

Please review and furnish a report to the Board. The Board next meets on October 20, 2011.

Thank you for your continued help and support.

Sincerely,

John H. McDaniel

John H. McDaniel
Vice President of Operations

JHM:tw

Attachments

cc: Board of Review
Counsel

United States Department of Agriculture | **Forest Service** | **Forest Products Laboratory** | **One Gifford Pinchot Drive Madison, WI 53705-2398**

File Code: 1350

Date: October 18, 2011

Tom D. Searles
Executive Vice President
Board of Review
American Lumber Standard Committee
P.O. Box 210
Germantown, MD 20875-0210

Dear Tom:

We have reviewed the Submission to ALSC BOR **Revised Design Values for Visually Graded Southern Pine Dimension Lumber** dated September 2011(revised October 2011). This submission presents an interim measure which adjusts all Southern Pine dimension lumber values based on destructive testing results for No. 2 grade 2 by 4 lumber in accordance with ASTM D1990 procedures.

Response:
The suggested reductions in No. 2 grade 2 by 4 dimension lumber design values are justified by the data presented and the proposed reductions of all size-grade values are a reasonable approach to establish interim values that are conservative until the full size-grade testing matrix test results are available.

Comments:
The reduction in specific gravity from 0.55 to 0.52 observed is a sizable reduction which is more in line with the current Mixed Southern Pine value.

Please call me if you have any questions. 608-231-0307.

Sincerely;

David E. Kretschmann, P.E.
Research General Engineer,
Engineering Properties of Wood, Wood Based Materials and Structures

cc:
Jim Loy
Bob Browder
Ronald Williams
Jay Moore
James Evans