Notice

The following document reflects points of discussion of the SPIB Technical Committee. It is an initial staff analysis of data obtained to support an update to the currently published design values for Southern Pine dimension lumber. The information presented is a preliminary assessment and is subject to revision during the ongoing review process. No external decisions should be made based on this information. The SPIB is sharing this information to reduce the occurence of false and misleading statements.

2012 Ingrade Testing Program

SPIB

Technical Committee Meeting

July 18-19, 2012

Brief Timeline

- Summer 2010 – Need for additional testing
- 2x4 #2 Test Plan approved by ALSC BOR
- 2011 reviewed 2x4 #2 results
- Test Plan to complete full matrix approved
  - 2 grades - SS and #2
  - 3 widths – 2x4, 2x8, 2x10
- Completed full matrix testing June 2012

Sampling

- Sampled across Southern Pine growing region
- Samples representative of production in region
- Used same geographic regions as used in IGT & RMP
- Target sample size of 360-400 pieces per size/grade/property - over 7400 overall
- All pieces “on-grade” verified by Quality Supervisor

Sampling (continued)

- Mills randomly selected within regions by FPL
- Lot size of 10 pieces per size/grade from sampled mills.
- Bending and Tension tested by SPIB
- Compression tested by TP
  - 2x10 tested at FPL due to machine capacity

Data Collected

- Dimensions
- Growth Characteristics
- Grade Controlling Characteristic
- Maximum Strength Reducing Characteristic
- Temperature & Moisture Content
- E-Computer E (full-length)
- Edge E (17:1 span to depth ratio)
- Failure Load
- Failure Code

Bending Data Collection

- Edge E collected on 17:1 span to depth ratio.
  - 2x4 used 59.5" span
  - 2x8 used 123.25" span
  - 2x10 used 157.25" span
    - 138" span for 12' 2x10, when longer length not available
- Lumber samples were 12' – 20' in length
- Loaded edge and defect randomly located

Tension Data Collection

- 8’ gauge length for all pieces
- Defects randomly located if length permitted.

Compression Data Collection

- Weight, dimensions, and MC collected for SG.
- Small specimens isolating two worst defects cut
  - 2x4 – 9" specimen
  - 2x8 – 18" specimen
  - 2x10 – 23" specimen

Weakest of two specimens used for UCS calculation.

Data Analysis

- Calculate properties (E, MOR, UTS, UCS)
- Adjust properties to 15% MC
- Convert to "Characteristic Size" – 2x8-12'
- Calculate summary statistics:
  - 5th Percentile Tolerance Limit for MOR, UTS, UCS
  - Average E

Data Sorts

With collected data, various sorts are possible:

- Dense, Medium Grain, Coarse Grain
- One end of piece, either end, both ends
- With or without pith
- Prime or Common
- Combination Knots

Definitions of Dense and Medium Grain

- Dense: On one end or the other, must be
  - 6 rpi and at least 1/3 summerwood, or
  - 4 rpi and at least ½ summerwood

- Medium Grain: On one end or the other, must be
  - 4 rpi, or
  - If less than 4 rpi, must have 1/3 summerwood

Brief Statistics Review

- For strength values, we need the 5th percentile
- Interested in three different estimates:
  - Point Estimate (PE) – basically 0.05 x sample size
  - Tolerance Limit (TL) – a value lower than the PE, in which we have "greater confidence"
  - Upper Confidence Limit (UCL) – a value higher than the PE. We have good confidence that the PE is not greater than the UCL
- Order Statistic
  - Ranking the strength values in order from weakest to strongest

Published Design Values per ASTM D1990

- 5th Percentile Tolerance Limit for strength
- Divide by a factor of 2.1
  - Adjusts for "safety factor"
  - Adjusts for loading rate
    - Fast testing vs. buildings standing for years
- Round Design Values for Publication
  - Nearest 50 psi for strength over 1000 psi
  - Nearest 25 psi for strength less than 1000 psi
  - Nearest 100,000 psi for E

ASTM D1990 Size Model

- A Full Matrix for IGT includes:
  - Minimum of 2 grades per size
    - Select Structural and #2
  - Minimum of 3 widths
    - 2x4, 2x8, 2x10
- Separate studies showed that strength varies by width and length
- Adjust all data to 2x8-12' to combine tested sizes
- Use size model to convert back to all sizes

Convert 2x4 test data to 2x8-12’

- Test span = 59.5”
- 5th percentile MOR = 2490 psi (2x4-59.5” basis)
- Convert to 2x8-12’ Characteristic Size:

$$MOR_{2x8} = MOR_{2x4'} * \left(\frac{3.5}{7.25}\right)^{0.29} * \left(\frac{59.5}{144}\right)^{0.14}$$

$$MOR_{2x8} = 2490 * (0.8096) * (0.8836)$$

$$MOR_{2x8} = 1781\ psi$$

“Sizes” of Interest

Test Size

- 2x4 1.5” x 3.5” 59.5” span for bending
- 2x8 1.5” x 7.25” 123.25” span
- 2x10 1.5” x 9.25” 157.25” span (138” span for 12’)
- All tension tests used 96” gauge length

Characteristic Size – 2x8-12’ 1.5” x 7.25” x 144”

Published Design Values
by width
12’ length for 2x4-2x8, 20’ length for 2x10, 2x12

Bending Data Summary

SS	n	Edge E	MC	SPG	OS75%TL	Char	Mills	Regions
2x4	420	1.84	14.8	0.57	18.5	3724	15	9
2x8	409	1.79	15.3	0.56	17.9	4099	13	6
2x10	410	1.77	15.1	0.56	18.0	4664	17	9
All SS	1239	1.80	15.0	0.56	57.3	4124	35	13
#2	n	Edge E	MC	SPG	OS75%TL	Char	Mills	Regions
2x4	409	1.36	11.2	0.51	17.9	1781	15	9
2x8	420	1.47	15.1	0.52	18.5	2092	15	9
2x10	420	1.50	15.4	0.52	18.5	2042	14	8
All #2	1249	1.45	13.9	0.52	57.7	1950	40	11

Two Required Data Checks

- ASTM D1990 Section 9.3
  - Compare model predicted values to Upper Confidence Limit for each cell
  - Reduce Characteristic Value for grade if limit exceeded
- ASTM D1990 Section 12.6
  - Compare predicted values to Point Estimate (+100psi) for each cell.
  - Reduce value for individual cell if limit exceeded

Test Cell Data Check – SS MOR

	Bending				9.3	
			Test Size	2x8-12'	Test Size	Revised
Grade	Size	n	MOR UCL	Char Value	Pred. MOR	Char Value
SS	2x4	420	5702	4124	5765	
	2x8	409	4476		4215	
	2x10	410	4564		3796	4079

Point Estimate Check

	Bending				12.6	
			Test Size	2x8-12'	Test Size	Revised
Grade	Size	n	MOR PE	Char Value	Pred. MOR	Cell Value
SS	2x4	420	5490	4079	5702	5590
	2x8	409	4298		4169	
	2x10	410	4360		3754	

Conclusion

- Because of grade and cell-specific data checks, the uniformity of the Grade/Size model can become somewhat distorted

- Can make comparisons and “what-if” questions tricky to evaluate.

Comparison to Original IGT

21:1 Edge E MOR at Characteristic Size

SS	2012	1991	% Diff	2012	1991	% Diff
2x4	1.841	1.824	0.9%	3724	4796	-22.4%
2x8	1.789	1.886	-5.1%	4099	4736	-13.5%
2x10	1.770	1.771	-0.1%	4664	5266	-11.4%
All SS	1.800	1.835	-1.9%	4079	4917	-17.0%
#2	2012	1991	% Diff	2012	1991	% Diff
2x4	1.355	1.531	-11.5%	1781	2593	-31.3%
2x8	1.474	1.595	-7.6%	2092	2464	-15.1%
2x10	1.505	1.490	1.0%	2042	2838	-28.0%
All #2	1.446	1.563	-7.5%	1916	2527	-24.2%

Tension Data Summary

SS	n	Edge E	MC	SPG	OS75%TL	Char	Mills	Regions
2x4	420	1.84	14.5	0.57	18.5	2729	15	8
2x8	410	1.80	15.2	0.56	18.0	2747	15	7
2x10	410	1.77	14.6	0.55	18.0	2957	13	6
All SS	1240	1.80	14.8	0.56	57.3	2804	35	13
#2	n	Edge E	MC	SPG	OS75%TL	Char	Mills	Regions
2x4	410	1.40	11.7	0.53	18.0	1105	13	8
2x8	420	1.52	14.7	0.53	18.5	1388	15	7
2x10	419	1.50	15.3	0.53	18.4	1332	16	9
All #2	1249	1.47	13.9	0.53	57.7	1248	43	13

Comparison to Original IGT

21:1 Edge E UTS at Characteristic Size

SS	2012	1991	% Diff	2012	1991	% Diff
2x4	1.844	1.857	-0.7%	2729	2555	6.8%
2x8	1.796	1.843	-2.5%	2747	2779	-1.2%
2x10	1.771	1.782	-0.6%	2957	2683	10.2%
All SS	1.801	1.827	-1.4%	2804	2698	3.9%
#2	2012	1991	% Diff	2012	1991	% Diff
2x4	1.399	1.488	-6.0%	1105	1428	-22.6%
2x8	1.520	1.603	-5.2%	1388	1340	3.6%
2x10	1.500	1.487	0.9%	1332	1330	0.2%
All #2	1.473	1.543	-4.5%	1121	1412	-20.6%

Compression Data Summary

SS	n	D MC	SPG	OS75%TL	Char
2x4	410	12.3	0.56	18.0	3527
2x8	400	13.3	0.54	17.5	3436
2x10	400	13.5	0.55	17.5	3440
All SS	1210	13.0	0.56	55.9	3480
#2	n	D MC	SPG	OS75%TL	Char
2x4	410	12.0	0.55	18.0	2674
2x8	410	12.8	0.52	18.0	2653
2x10	410	13.9	0.52	18.0	2668
All #2	1230	12.9	0.52	56.8	2675

Comparison to Original IGT

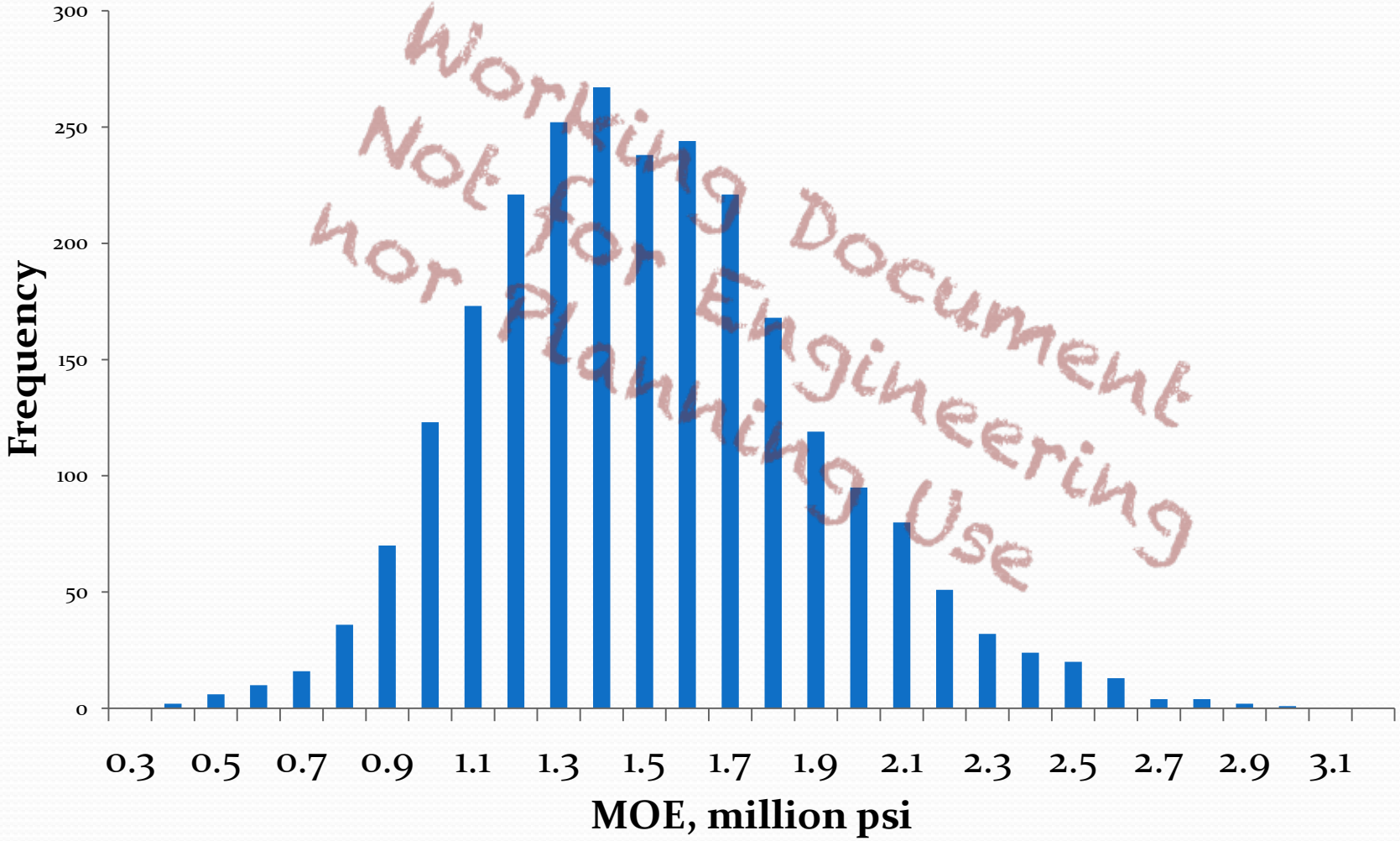
UCS at Characteristic Width

SS	2012	1991	% Diff
2x4	3527	3834	-8.0%
2x8	3436	3754	-8.5%
2x10	3440	3935	-12.6%
All SS	3480	3849	-9.6%
#2	2012	1991	% Diff
2x4	2674	2856	-6.4%
2x8	2653	2900	-8.5%
2x10	2668	2874	-7.2%
All #2	2675	2901	-7.8%

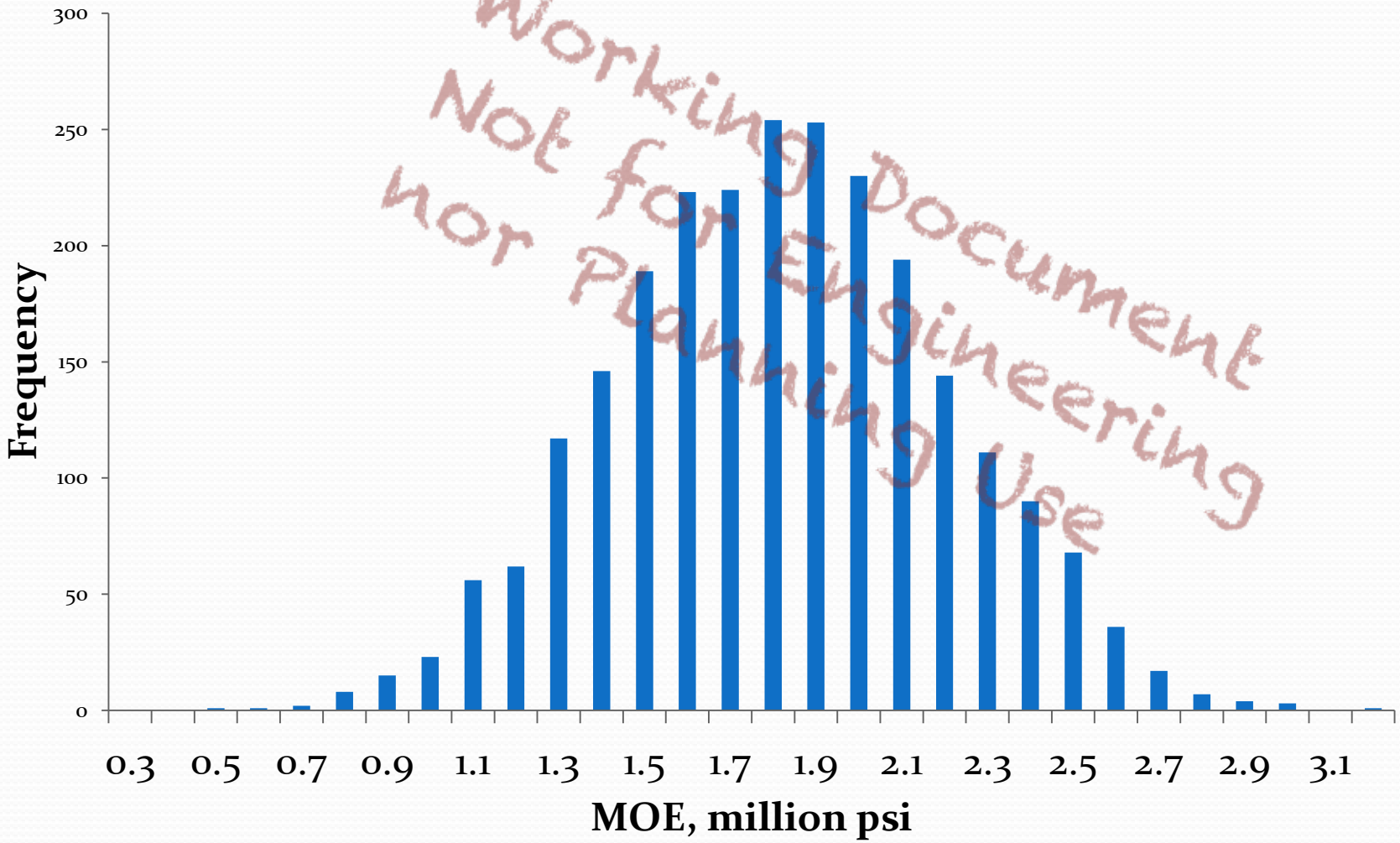
MOE Data

- Used edge E data from all bending and tension specimens
- Converted to 21:1 span to depth ratio

Histogram for #2 MOE



Histogram for SS MOE



Results of Grade Model

		MOR		UTS			UCS	
	SR	2x8-12'	1991 Char	2x8-12'	1991 Char	SR	2x8	1991 Char
SS	0.65	4079	4917	2804	2698	0.69	3306	3657
#1	0.55	2548		1668		0.62	2894	
#2	0.45	1916	2524	1121	1412	0.52	2675	2901
#3, Stud	0.26	1107		648		0.30	1543	
Constr.	0.34	1448		847		0.56	2881	
Std	0.19	809		473		0.46	2366	
Util	0.09	383		224		0.30	1543	

2x4 Proposed Design Values

2x4	Proposed	2011 DV	Proposed	2011 DV	Proposed	2011 DV	Proposed	2011
	Fb		Ft		Fc		E	
SS	2350	2850	1650	1600	1900	2100	1.8	1.8
#1	1500	1850	1000	1050	1650	1850	1.6	1.7
#2	1100	1500/1050	650	825/650	1550	1650/1100	1.5	1.6/1.4
#3, Stud	650	850/600	375	475/375	900	975/625	1.3	1.4/1.2
Constr.	850	1100/800	500	625/500	1650	1800/1150	1.4	1.5/1.3
Std	475	625/450	275	350/275	1350	1500/950	1.2	1.3/1.2
Util	225	300/200	125	175/125	900	975/625	1.2	1.3/1.2

2x6 Proposed Design Values

2x6	Proposed	2011 DV	Proposed	2011 DV	Proposed	2011 DV	Proposed	2011
	Fb		Ft		Fc		E	
SS	2100	2550	1450	1400	1800	2000	1.8	1.8
#1	1300	1650	850	900	1600	1750	1.6	1.7
#2	1000	1250	575	725	1450	1600	1.5	1.6
#3, Stud	575	750	325	425	850	925	1.3	1.4

2x8 Proposed Design Values

2x8	Proposed	2011 DV	Proposed	2011 DV	Proposed	2011 DV	Proposed	2011
	Fb		Ft		Fc		E	
SS	1950	2300	1350	1300	1750	1900	1.8	1.8
#1	1200	1500	800	825	1500	1650	1.6	1.7
#2	900	1200	525	650	1400	1550	1.5	1.6
#3, Stud	525	700	300	400	800	875	1.3	1.4

2x10 Proposed Design Values

2x10	Proposed	2011 DV	Proposed	2011 DV	Proposed	2011 DV	Proposed	2011
	Fb		Ft		Fc		E	
SS	1700	2050	1150	1100	1700	1850	1.8	1.8
#1	1050	1300	700	725	1500	1600	1.6	1.7
#2	800	1050	475	575	1350	1500	1.5	1.6
#3, Stud	450	600	275	325	775	850	1.3	1.4

2x12 Proposed Design Values

2x12	Proposed	2011 DV	Proposed	2011 DV	Proposed	2011 DV	Proposed	2011
	Fb		Ft		Fc		E	
SS	1600	1900	1100	1050	1650	1800	1.8	1.8
#1	1000	1250	650	675	1450	1600	1.6	1.7
#2	750	975	450	550	1350	1450	1.5	1.6
#3, Stud	425	575	250	325	775	825	1.3	1.4

Specific Gravity

- Average value for entire species

Property	Sample Size	Specific Gravity
Bending	2488	0.540
Tension	2489	0.543
Compression	2440	0.538
Total	7417	0.540

Prime Grades
Bending Factors

SS	n	Edge E	Factor	OS75%TL	Char	Factor
All SS	1239	1.80		57.3	4124	
SS P	675	1.77	0.98	30.4	4079	0.99
SS C	564	1.84	1.02	25.2	4160	1.01
#2	n	Edge E	Factor	OS75%TL	Char	Factor
All #2	1249	1.45		57.7	1950	
#2 P	391	1.37	0.94	17.1	1825	0.94
#2 C	858	1.48	1.03	39.1	2082	1.07

Prime Grades
Tension Factors

SS	n	Edge E	Factor	OS75%TL	Char	Factor
All SS	1240	1.80		57.3	2804	
SS P	687	1.77	0.99	31.0	2584	0.92
SS C	553	1.83	1.02	24.7	3175	1.13
#2	n	Edge E	Factor	OS75%TL	Char	Factor
All #2	1249	1.47		57.7	1248	
#2 P	348	1.36	0.93	15.1	1094	0.88
#2 C	901	1.51	1.03	41.1	1340	1.07

Prime Grades Compression Factors

SS	n	OS75%TL	Char	Factor
All SS	1210	55.9	3480	
SS P	686	30.9	3416	0.98
SS C	524	23.3	3613	1.04
#2	n	OS75%TL	Char	Factor
All #2	1230	56.8	2675	
#2 P	323	14.0	2668	1.00
#2 C	907	41.4	2694	1.01

Prime Grades

- Reductions vary by grade
- Actual reductions may be less after grade and cell specific data checks
- Production of Prime is limited
- Complicating issues with “Prime” vs “#2 Wane-free”

Dense Southern Pine

- Original IGT used “factors” for each property and grade to determine increases for dense.
- In 2011, FPL indicated factors may not be appropriate
  - Factors rely on “unclassified values” remaining stable
  - Percentage of dense material has changed over time
- Look at current dense/nondense data using size/grade models

2x4 Dense, Uncl., Nondense

	Proposed Fb	2011	Proposed Ft	2011	Proposed Fc	2011	Proposed E	2011
DSS	2550	3050	1850	1650	2050	2250	1.9	1.9
SS	2350	2850	1650	1600	1900	2100	1.8	1.8
NDSS	1950	2650	1050	1350	1800	1950	1.6	1.7
#1D	1700	2000	1150	1100	1750	2000	1.8	1.8
#1	1500	1850	1000	1050	1650	1850	1.6	1.7
#1N	1300	1700	900	900	1600	1700	1.5	1.6
#2D	1200	1700	800	875	1600	1850	1.6	1.7
#2	1100	1500	650	825	1550	1650	1.5	1.6
#2N	1050	1350	625	775	1500	1600	1.3	1.4

2x6 Dense, Uncl., Nondense

	Proposed Fb	2011	Proposed Ft	2011	Proposed Fc	2011	Proposed E	2011
DSS	2400	2700	1650	1500	1950	2150	1.9	1.9
SS	2100	2550	1450	1400	1800	2000	1.8	1.8
NDSS	1800	2350	1300	1200	1700	1850	1.6	1.7
#1D	1500	1750	1000	950	1650	1900	1.8	1.8
#1	1300	1650	850	900	1600	1750	1.6	1.7
#1N	1150	1500	775	800	1500	1600	1.5	1.6
#2D	1050	1400	725	775	1500	1750	1.6	1.7
#2	1000	1250	575	725	1450	1600	1.5	1.6
#2N	900	1150	550	675	1400	1500	1.3	1.4

2x8 Dense, Uncl., Nondense

	Proposed Fb	2011	Proposed Ft	2011	Proposed Fc	2011	Proposed E	2011
DSS	2200	2450	1500	1350	1850	2050	1.9	1.9
SS	1950	2300	1350	1300	1750	1900	1.8	1.8
NDSS	1650	2100	1200	1100	1650	1750	1.6	1.7
#1D	1350	1650	925	875	1600	1800	1.8	1.8
#1	1200	1500	800	825	1500	1650	1.6	1.7
#1N	1050	1350	725	725	1450	1550	1.5	1.6
#2D	1000	1400	675	675	1450	1700	1.6	1.7
#2	900	1200	525	650	1400	1550	1.5	1.6
#2N	825	1100	500	600	1350	1450	1.3	1.4

2x10 Dense, Uncl., Nondense

	Proposed Fb	2011	Proposed Ft	2011	Proposed Fc	2011	Proposed E	2011
DSS	1950	2150	1300	1200	1800	2000	1.9	1.9
SS	1700	2050	1150	1100	1700	1850	1.8	1.8
NDSS	1400	1850	1000	950	1600	1750	1.6	1.7
#1D	1200	1450	800	775	1550	1750	1.8	1.8
#1	1050	1300	700	725	1500	1600	1.6	1.7
#1N	900	1200	625	650	1400	1500	1.5	1.6
#2D	850	1200	575	625	1400	1650	1.6	1.7
#2	800	1050	475	575	1350	1500	1.5	1.6
#2N	725	950	425	550	1350	1400	1.3	1.4

2x12 Dense, Uncl., Nondense

	Proposed Fb	2011	Proposed Ft	2011	Proposed Fc	2011	Proposed E	2011
DSS	1800	2050	1250	1100	1750	1950	1.9	1.9
SS	1600	1900	1100	1050	1650	1800	1.8	1.8
NDSS	1350	1750	975	900	1550	1700	1.6	1.7
#1D	1100	1350	750	725	1500	1700	1.8	1.8
#1	1000	1250	650	675	1450	1600	1.6	1.7
#1N	850	1150	575	600	1350	1500	1.5	1.6
#2D	825	1150	550	575	1350	1600	1.6	1.7
#2	750	975	450	550	1350	1450	1.5	1.6
#2N	675	900	400	525	1300	1350	1.3	1.4

Compression Perpendicular

- Not addressed in ASTM D1990
- Based on D2555 and D245
- Not grade-dependent
- Currently have different values based on density:
  - Dense = 660 psi
  - Unclassified = 565 psi
  - Nondense = 480 psi

Horizontal Shear, Fv

- Not addressed in ASTM D1990
- Based on D2555 and D245
- Not grade-dependent
- Not density-dependent
- Currently set at 175 psi for all major Southern Pine