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MEAN AND TOLERANCE LIMIT STRESSES AND STRESS MODELING FOR COMPR--ETC(U)
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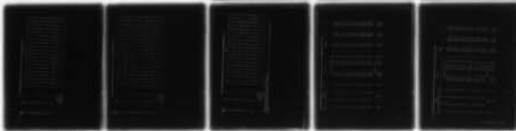
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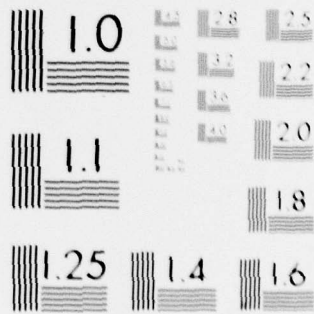
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Stresses and Stress Modeling
for Compression Perpendicular
to Grain in Hardwood and
Softwood Species.

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B. Alan/Bendtsen
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Abstract

Tables characterizing the stress-compression relationship of wood in compression perpendicular to grain for several species are presented here. Complete characterization results are included, as well as selected regression models for characterizing other species. Use of the tables and models is illustrated via discussion and graphs.

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Mean and Tolerance Limit Stresses and Stress Modeling for Compression Perpendicular to Grain in Hardwood and Softwood Species

By
B. ALAN BENDTSEN
and
WILLIAM L. GALLIGAN

Earlier research into procedures for characterizing stress-compression behavior in wood for compression perpendicular to grain (C-perp), and for modeling this behavior, was published.^{2,3} This paper presents more detailed results of the previous research.

Background

Allowable design stresses for wood in C-perp are currently based upon the average proportional limit (PL) stress determined from tests of small, clear specimens. This design base is excessively conservative. A need for a more appropriate C-perp design base has become apparent because of today's more efficient engineering design with wood.

Thus, a procedure was developed for characterizing the C-perp stress-compression relationship of wood.³ This characterization procedure utilizes the original test records of specimen test results that form the current C-perp design base⁴—no new testing is required.

The procedures previously reported³ were used to characterize the C-perp behavior of nine softwood and hardwood species or species subgroups: Coast Douglas-fir, interior north Douglas-fir, shortleaf pine, western hemlock, Engelmann spruce, white spruce, Pacific silver fir, aspen, and northern red oak. This research is reported in footnote 2. The output for each species characterization consists of: (1) nonparametric tolerance limit stresses for each of 20 levels of

compression and for all combinations of six tolerance regions, ranging from 50 to 90 percent content, and five confidence levels from 75 to 99 percent; (2) the mean (\bar{x}), standard deviation (s), and coefficient of variation for stresses at each level of compression; and (3) dry/green ratios for average interpolated stresses at each compression level.

Characterization results from the nine species or species subgroups were used by the authors² in the development of a number of different models for predicting the stress-compression behavior in wood at both the mean and near minimum stress levels. Several different predictors were employed as independent variables and logarithmic transformations of both the dependent and independent variables were explored.

The simple linear regression model containing the average D 2555⁴ C-perp PL as the predictor variable provided the "best fit" of the models explored. The appropriateness of this model to the current visual stress grading system in the United States was illustrated by application to white fir. The model is applicable to all species tabulated in D 2555.

Only highly abridged characterization results for one species and the one model containing the average C-perp PL were published earlier.² However, models containing modulus of elasticity (E) and specific gravity (SG) as the predictor variable may also be germane to improving the grading technology.

For example, in current practices for both visual and machine stress rated

(MSR) lumber, no distinction is made between grades for C-perp allowable stresses: the same stress is assigned to all grades. Models containing E as a predictor may provide a basis for assigning C-perp stresses in MSR grading systems in accord with current practice for other properties. Similarly, SG may be an appropriate nondestructive test parameter for grade-dependent C-perp allowable values in the current visual grading system. SG at least could provide a basis for assigning a "bonus" to grades of high density.

This possible interest in further developments of visual and MSR grading systems, and the lack of published information on C-perp stress-compression behavior—particularly at near-minimum stress levels—suggest the value of complete characterization results (table 1) and selected regression results for models containing E and SG (tables 2 and 3).

¹Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

²Bendtsen, B. A., and W. L. Galligan. 1979. Modeling the stress-compression relationships in wood in compression perpendicular to grain. *For. Prod. J.* 29(2):42-48.

³Bendtsen, B. A., J. H. Haskell, and W. L. Galligan. 1977. Characterizing the stress-compression relationship of wood in compression perpendicular to grain. *Wood Sci.* 10(3):111-121.

⁴American Society for Testing and Materials. 1978. Standard methods for establishing clear wood strength values. ASTM design. D 2555-76. Philadelphia, Pa.

Interpretation and Use of the Tables

Characterization results for the nine species or species subgroups previously evaluated² are given in table 1. Individual stress values in the table represent either a species average stress or a tolerance limit stress for a given species and compression level. For example, the mean stress for a Coast Douglas-fir at the 0.05-inch level of compression is 738 pounds per square inch (lb/in.²) (p. 1, 4th line from bottom under the heading "0.050"). If the 25 percent tolerance limit (75 pct tolerance region content) with 75 percent confidence is desired for the 0.05-inch level of compression, the appropriate line is selected using the first two columns on the left. Reading across to the "0.050" column, the tolerance limit is 568 lb/in.² (which reflects the strength of the 156th weakest of the sample of 654 specimens for Coast Douglas-fir—see column heading "m").

The characterization process³ demonstrated that the stress required to achieve a deformation is a highly skewed distribution. That is one reason why the nonparametric approach was used for determining the tolerance limits in table 1. The standard deviations and coefficients of variation reported in table 1 should be used with caution because of the demonstrated skewness.

Stresses from any single line in table 1, when plotted as a function of compression level, illustrate stress-compression relationships for a species at a mean or a tolerance limit level. Figure 1 shows such plots for shortleaf pine. The top line of the figure represents mean behavior; the two lower lines are tolerance limits.

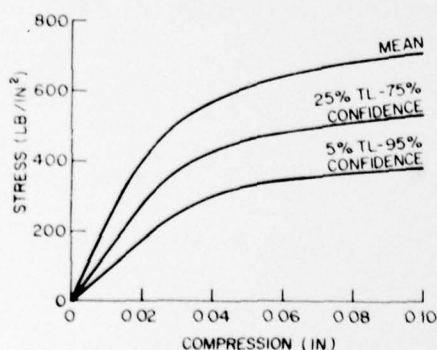


Figure 1.—Stress-compression behavior for the mean and two tolerance limits (TL) of shortleaf pine. (M 146 878)

Figure 1 is not presented as an analysis of results. Rather, it demonstrates the interpretation and use of table 1 data. Interpretation of the mean behavior line in figure 1 is obvious; the tolerance limit lines are somewhat less so. The bottom line, for example, should be interpreted as follows: We are 95 percent confident that 95 percent of shortleaf pine material will exceed stresses interpolated from the line.

Regression statistics for models containing modulus of elasticity, E as the predictor variable are presented in table 2. Similar statistics for specific gravity, SG, as the predictor appear in table 3. The model containing E is:

$$\log_{10} \hat{y} = A + B \log_{10} x$$

where

\hat{y} = an estimated mean or tolerance limit stress for any compression level of interest,
 x = a species average E value from D 2555, and

A and B = appropriate regression statistics from table 2.

The model using SG as the predictor variable is:

$$\hat{y} = A + Bx$$

where

x = a species average SG value from D 2555 and

A and B = appropriate regression statistics from table 3.

These models were selected as best fitting, based upon R² analysis, from those containing E and SG as estimators. Details of the development and application of the models are similar to those for the model involving the C-perp PL.²

The models containing E and SG are illustrated in figures 2 and 3 for the mean and the 25 percent tolerance limit (75 pct confidence) at 0.06-inch compression. Values of \hat{y} for the regressions in figures 2 and 3 are obtained from table 1—one value for each of the nine species evaluated. Values of x are either an average E value (fig. 2) or an average SG value (fig. 3) from ASTM D 2555⁴ for corresponding species. In each figure, the upper line is a model for estimating mean behavior; the lower line, near minimum or a tolerance limit behavior. Note that a tolerance limit has confidence associated with it. However, the estimated tolerance limits obtained from these models do not. Confidence in these estimates, if desired, is

obtained by standard procedures for calculating lower limits on regression estimates of values of \hat{y} .⁵ Statistics for making this computation are included in tables 2 and 3.

A composite diagram of the mean or a near minimum stress-compression behavior from zero to 0.1-inch compression can be developed for any species using table 2 or table 3 data. For example, mean behavior is obtained by use of regressions 31 through 35 from either table; the 25 percent tolerance limit with 75 percent confidence is obtained with regressions 11 through 15. If a species has an average E of 1.6 million lb/in.², estimated mean stresses and those for the tolerance limit and confidence mentioned are:

Compression level	Mean stress	Tolerance limit stress
in.	Lb/in. ²	Lb/in. ²
0.02	551	393
04	738	561
06	813	631
08	871	668
1.0	923	713

and the stress-compression diagrams appear as in figure 4. Stresses in the tabulation here are not design stresses. Further modifications for ring angle, seasoning, and design considerations may be required. One method for making those modifications is detailed in an example presented elsewhere.² In that example, the average C-perp PL is used as the estimator variable. However, details of the procedures outlined in the example are also applicable to stresses developed using either E or SG as the predictor.

Summary

Detailed results of earlier research on the stress-compression relationships in C-perp for several softwood and hardwood species are given in table 1. The mean C-perp stress, standard deviation, coefficient of variation, and several nonparametric tolerance limit stresses are tabulated. Ratios of the average dry to the average green stresses are also given for each compression level. Graphical interpretation of selected data for shortleaf pine is given in figure 1 to illustrate the development of composite

⁵Freese, Frank. 1974. Elementary statistical methods for foresters. U.S. Dep. Agric., Handb. 317. Washington, D.C.

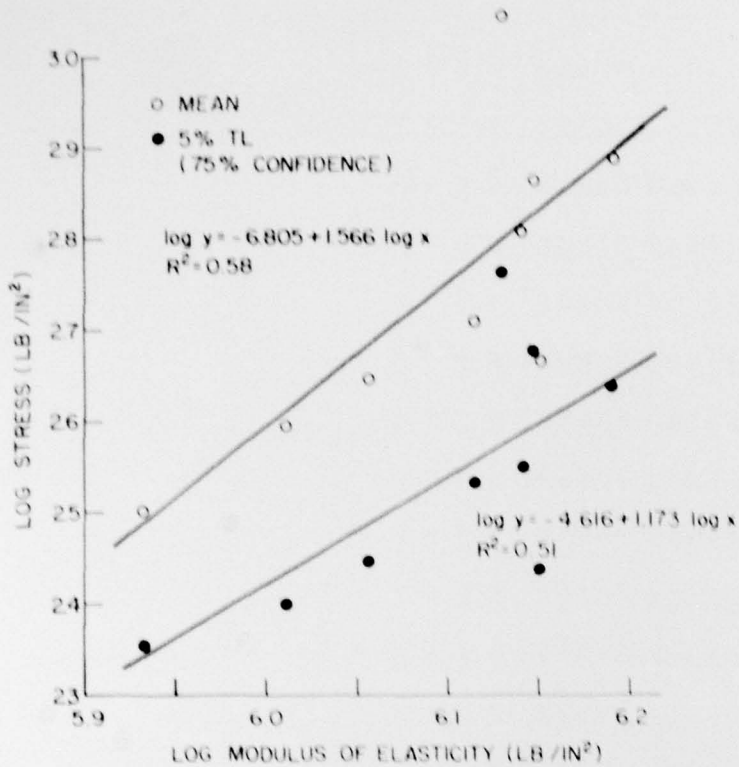


Figure 2.—Regression models with modulus of elasticity as a predictor for estimating mean and tolerance limit (TL) stresses at the 0.06-inch level of compression.

(M 146 880)

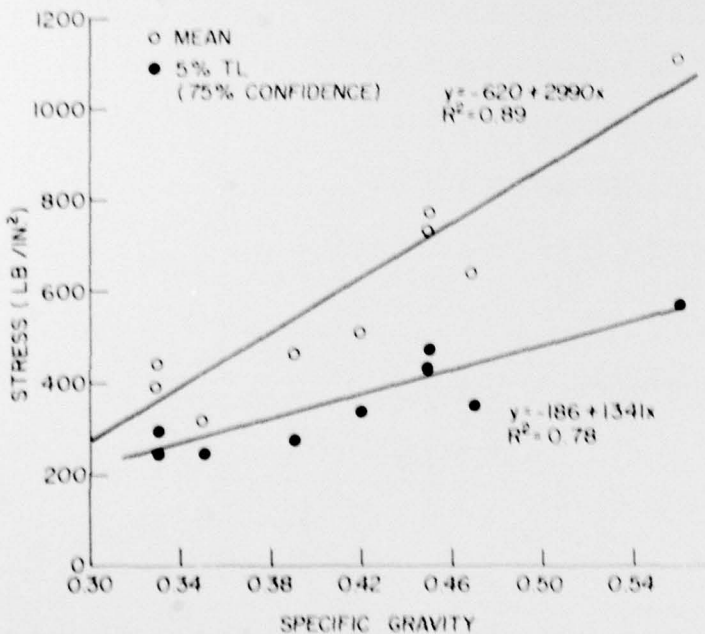


Figure 3.—Regression models, with specific gravity as a predictor, for estimating mean and tolerance limit (TL) stresses at the 0.06-inch level of compression.

(M 146 881)

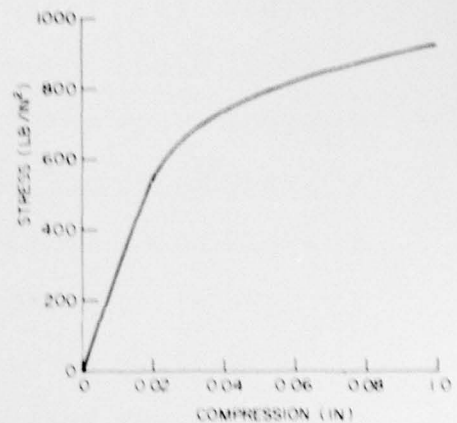


Figure 4.—Estimated stress-compression behavior at the mean and a tolerance limit level in a species assumed to have an average modulus of elasticity of 1.6×10^6 lb/in.².

(M 146 879)

stress-compression diagrams from table 1 data.

The data in table 1 were used in earlier research for developing models for predicting C-perp stress-compression behavior in D 2555 species. Parameters for regression models using species average E or SG values as predictor variables are presented in tables 2 and 3. The models are illustrated for the mean and a selected tolerance limit at the 0.06-inch level of compression in figures 2 and 3, and for the development of the stress-compression behavior for a species in figure 4. Figures 2, 3, and 4 are presented to demonstrate the use of the regression models in tables 2 and 3.

Table 1. - Mean, standard deviation, coefficient of variation, tolerance limits,¹ and the dry/green ratio for each of 20 compression levels (Coast Douglas-fir)

Tolerance Region Content (Pct. β)	Confidence (Pct. α)	m ²	Compression (in.)																				
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	
95	95	1	26	57	96	116	145	172	198	218	233	242	246	249	248	248	247	249	250	253	257	262	262
95	95	3	28	59	95	134	187	202	234	265	297	324	343	364	375	383	388	390	398	408	415	420	424
90	90	3	28	59	95	134	187	202	234	265	297	324	343	364	375	383	388	390	398	408	415	420	424
80	80	5	36	65	104	145	185	200	261	284	304	327	349	367	377	386	393	397	403	409	415	421	428
75	75	5	35	71	106	149	185	211	267	294	315	336	355	367	379	392	403	409	413	417	422	428	438
95	95	20	50	98	144	196	243	283	312	350	372	388	405	422	433	442	451	459	464	471	476	483	483
95	95	24	52	107	156	210	259	296	327	376	396	414	427	441	449	456	464	471	476	483	488	491	491
95	95	26	53	108	160	214	263	305	331	378	398	414	427	441	449	456	464	471	476	483	488	491	491
80	80	28	54	110	161	214	266	311	336	385	395	408	423	435	446	455	464	470	477	481	486	490	494
95	95	28	55	110	161	214	266	311	340	385	397	408	424	435	447	457	465	472	477	482	485	490	492
95	95	49	67	128	187	251	299	346	380	416	439	452	465	477	487	494	503	510	517	527	532	535	535
95	95	53	68	133	195	258	305	359	384	424	445	459	471	483	492	499	507	516	523	530	538	543	543
90	90	56	70	136	202	260	312	365	403	426	447	463	476	486	493	501	509	520	525	534	540	546	546
80	80	59	71	141	207	267	318	370	407	431	450	465	479	487	495	506	514	522	530	537	542	546	546
95	95	72	143	210	269	321	371	425	459	482	506	523	540	558	568	578	586	596	603	612	622	631	636
95	95	107	183	279	331	386	426	455	485	507	521	521	525	549	561	568	575	583	591	599	605	617	617
95	95	114	188	275	340	396	437	465	491	513	513	514	514	544	557	567	573	581	589	603	610	618	624
90	90	118	193	277	345	401	446	470	496	516	516	516	516	548	563	573	581	589	596	607	614	623	632
80	80	122	196	280	355	407	451	477	502	520	520	520	520	556	567	576	584	593	600	612	621	627	636
95	95	124	197	286	360	428	453	482	506	522	540	540	540	588	598	606	616	626	633	642	652	661	666
95	95	138	205	298	373	425	468	497	522	540	540	540	540	589	599	608	618	628	638	644	654	662	662
95	95	145	212	304	380	432	478	507	528	544	560	560	560	604	614	624	634	642	652	660	668	677	680
90	90	149	213	306	382	434	482	511	530	548	548	548	548	608	618	628	638	646	656	664	673	682	686
95	95	154	216	310	386	439	488	515	531	552	567	567	567	600	610	620	630	638	648	656	665	674	683
95	95	156	217	311	387	445	491	517	536	553	563	563	563	606	616	626	636	644	654	661	669	678	687
95	95	207	303	428	519	584	625	649	674	691	708	726	741	755	766	786	793	801	812	822	830	838	846
95	95	206	308	438	527	590	634	656	681	697	716	731	747	759	773	786	797	809	820	829	837	844	852
90	90	211	313	439	526	593	638	662	685	703	718	734	751	763	778	788	802	814	824	833	841	849	857
95	95	215	317	441	533	596	647	669	692	707	722	738	753	768	781	793	806	816	826	835	843	849	857
95	95	218	317	442	535	598	647	670	694	709	722	740	755	769	784	795	807	818	827	836	843	849	857
MEAN (n=554)			177	339	459	546	624	647	676	700	720	738	754	770	784	798	810	822	833	844	854	864	864
STANDARD DEVIATION			101	154	192	205	208	208	207	207	208	210	213	215	218	222	225	228	231	233	235	237	237
COEFFICIENT OF VARIATION			57	43	42	38	34	32	31	30	29	28	28	28	28	28	28	28	28	28	28	28	27
DRY/GREEN RATIO			1.75	1.79	1.83	1.88	1.92	1.93	1.93	1.92	1.91	1.90	1.87	1.85	1.83	1.81	1.80	1.78	1.77	1.76	1.75	1.75	1.74

Table 1. - Mean, standard deviation, coefficient of variation, tolerance limits,¹ and the dry green ratio for each of 20 compression levels (Interior north Douglas-fir)—continued

Tolerance region Content (Pct. B)	Confidence (Pct. α)	m ²	Compression (in.)																				
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	
99	90	47	100	145	179	245	309	337	360	377	392	403	411	419	426	434	442	450	457	464	470	470	
99	80	47	100	145	179	245	309	337	360	377	392	403	411	419	426	434	442	450	457	464	470	470	
99	75	47	100	145	179	245	309	337	360	377	392	403	411	419	426	434	442	450	457	464	470	470	
95	99	60	113	169	231	285	331	366	397	412	427	437	446	456	467	476	483	490	498	507	515	515	
95	95	66	132	191	256	297	342	382	409	420	438	447	455	462	469	477	488	498	503	510	517	517	
95	90	69	134	192	263	315	358	386	413	427	445	454	463	470	479	485	492	499	510	519	529	529	
95	80	70	134	198	264	321	371	396	414	433	447	462	470	477	482	488	497	502	510	521	530	530	
95	75	70	134	203	271	322	372	397	414	441	452	466	475	478	484	491	497	506	513	522	535	535	
90	99	74	142	212	276	337	379	415	442	460	471	480	487	495	506	515	523	528	532	549	551	551	
90	95	78	146	216	282	341	387	421	443	466	483	495	504	511	521	531	539	545	551	556	565	565	
90	90	80	146	222	293	346	395	423	457	469	486	499	508	522	535	538	543	549	552	561	574	574	
90	80	80	157	224	304	355	400	434	462	479	497	506	517	528	538	546	550	556	566	572	578	578	
90	75	81	159	233	307	359	400	436	463	484	498	509	518	529	538	546	554	561	568	573	580	580	
80	99	87	172	257	327	389	441	468	501	516	530	538	551	561	569	578	588	594	597	603	607	607	
95	95	91	174	265	334	393	450	483	508	520	533	547	559	566	576	581	592	601	610	621	632	632	
90	90	93	176	268	342	398	454	487	513	531	544	555	564	574	584	595	606	616	625	630	634	634	
80	80	95	183	273	350	401	461	494	515	534	551	562	572	580	588	598	608	619	628	634	638	638	
80	75	95	184	276	354	403	465	501	516	538	553	564	574	584	596	605	612	622	629	637	640	640	
75	99	95	184	276	355	408	465	502	523	539	554	565	577	586	597	607	617	625	629	637	644	644	
75	95	99	192	284	360	417	474	511	530	547	563	576	584	595	606	615	623	633	638	648	659	659	
75	90	100	197	285	364	422	477	517	539	553	569	581	591	600	611	621	632	641	645	655	663	663	
75	80	103	202	286	370	428	478	520	547	561	574	588	596	608	619	628	637	645	658	668	674	674	
75	75	104	203	287	371	433	481	521	548	562	575	589	600	610	620	628	637	648	658	668	678	678	
50	99	130	260	365	455	522	575	607	624	639	652	664	675	688	700	710	721	734	741	750	760	760	
50	95	132	264	370	459	524	584	618	630	644	662	674	686	696	708	715	725	735	745	755	766	766	
50	90	133	265	374	465	526	589	622	639	656	668	678	688	699	709	719	730	739	748	758	767	767	
50	80	135	270	378	468	530	593	623	642	659	675	687	698	706	714	724	732	744	755	765	781	781	
50	75	137	270	379	468	535	594	625	642	659	675	689	698	707	715	724	735	748	757	773	783	783	
			MEAN (n=237)	149	293	408	496	562	612	645	669	687	703	717	729	741	753	764	775	786	796	805	815
			STANDARD DEVIATION	55	107	136	151	158	161	163	165	166	168	169	171	174	176	179	181	184	186	187	189
			COEFFICIENT OF VARIATION	37	37	33	30	28	26	25	25	24	24	24	23	23	23	23	23	23	23	23	23
			DRY/GREEN RATIO ²																				

Table 1. - Mean, standard deviation, coefficient of variation, tolerance limits, and the dry/green ratio for each of 20 compression levels (Western hemlock) - continued

Tolerance region Content (Pct. β)	Confidence (Pct. α)	m ²	Compression (m.)																			
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
99	80	1	31	63	97	133	164	193	212	227	240	252	263	272	279	283	287	291	295	299	304	308
99	75	1	31	63	97	133	164	193	212	227	240	252	263	272	279	283	287	291	295	299	304	308
95	99	4	35	70	105	139	174	212	241	268	283	294	309	330	343	351	358	363	368	367	371	376
95	95	6	40	79	115	157	201	229	250	274	296	311	325	337	348	357	363	366	371	376	381	386
95	90	7	41	81	119	162	201	231	255	277	299	315	328	338	348	357	363	371	379	384	390	395
95	80	8	41	82	120	164	201	232	257	280	303	319	331	341	349	360	364	372	379	386	392	397
95	75	8	41	82	120	164	201	232	257	280	303	319	331	341	349	360	364	372	379	386	392	397
90	99	12	45	90	134	177	214	248	269	288	311	328	341	352	358	366	376	383	388	395	399	402
95	95	14	46	91	136	181	219	254	278	301	316	333	348	359	364	372	379	387	393	401	407	411
90	90	16	46	92	136	183	222	256	280	303	322	340	356	363	368	374	381	391	396	405	409	415
90	80	17	46	93	140	184	225	257	283	307	330	344	356	364	372	380	388	394	400	405	410	419
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95	95	33	52	105	152	207	243	281	313	332	351	363	373	386	395	403	409	418	425	432	439	445
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80	80	37	54	107	158	210	249	287	315	340	354	366	378	390	399	406	413	420	427	435	442	447
80	75	38	56	108	161	210	250	290	317	341	355	367	379	391	401	407	414	421	428	436	443	450
75	99	38	56	108	161	210	250	290	317	341	355	367	379	391	401	407	414	421	428	436	443	450
75	95	42	56	116	171	218	258	292	319	343	360	374	385	395	405	415	421	429	436	440	446	453
75	90	45	59	118	175	224	260	295	323	345	364	377	389	399	407	417	426	432	440	447	453	454
80	80	47	60	121	177	228	263	296	324	348	365	379	391	400	408	418	427	433	440	447	455	459
75	75	48	60	121	177	228	264	297	324	348	367	381	391	400	409	420	427	433	441	450	456	460
50	99	88	75	153	218	278	326	363	381	400	412	422	435	448	461	471	480	488	492	496	506	514
50	95	93	76	156	224	286	333	369	397	408	421	433	444	455	467	478	487	496	504	509	517	524
50	90	96	77	159	227	293	340	375	402	416	427	440	449	460	471	481	489	497	506	515	522	530
50	80	99	77	160	231	294	345	382	408	426	436	448	454	467	475	486	493	502	512	523	531	537
50	75	100	78	160	233	294	349	384	410	428	436	448	456	467	479	487	497	506	514	523	533	542
			87	174	250	318	370	409	435	457	474	489	501	513	523	534	543	551	560	568	576	584
STANDARD DEVIATION			38	75	98	114	121	126	128	130	132	133	135	137	139	141	143	145	147	149	151	153
COEFFICIENT OF VARIATION			44	43	39	36	33	31	29	28	28	27	27	27	27	27	26	26	26	26	26	26
DRY/GREEN RATIO			1.94	1.96	2.01	2.01	2.00	1.99	1.98	1.98	1.98	1.97	1.96	1.96	1.96	1.95	1.94	1.94	1.93	1.92	1.91	1.91

Table 1. - Mean, standard deviation, coefficient of variation, tolerance limits,¹ and the dry/green ratio for each of 20 compression levels (Pacific silver fir)—continued

Tolerance Region Content (Pct. B)	Confidence (Pct. a)	m ²	Compression (in.)																			
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
95	99	2	26	52	75	99	122	146	169	190	206	218	227	235	243	248	253	257	261	264	267	270
95	95	3	27	55	83	111	135	157	174	191	208	221	236	248	258	266	274	281	287	292	297	303
95	90	4	32	60	83	115	149	174	195	215	240	254	259	264	268	272	277	282	288	295	300	304
95	80	5	36	70	103	137	172	208	234	242	249	255	266	275	283	292	299	307	313	320	325	328
95	75	5	36	70	103	137	172	208	234	242	249	255	266	275	283	292	299	307	313	320	325	328
90	99	6	37	74	112	148	181	212	236	257	272	272	275	282	290	300	310	314	318	321	326	333
90	95	8	39	79	114	152	185	223	245	264	274	282	290	302	314	318	322	327	332	338	345	350
90	90	9	44	90	121	160	198	226	247	266	276	283	293	304	314	321	326	331	335	340	346	353
90	80	11	47	91	132	176	209	237	258	271	278	294	309	313	315	324	332	339	346	351	354	355
90	75	11	47	91	132	176	209	237	258	271	278	294	309	313	315	324	332	339	346	351	354	355
80	99	17	49	96	140	186	219	254	271	280	295	306	316	325	333	340	347	353	361	367	372	380
80	95	20	50	100	146	190	230	264	278	300	307	317	319	326	338	350	359	366	372	377	381	386
80	90	21	51	101	147	193	234	264	285	303	315	318	321	327	341	351	359	368	377	384	389	398
80	80	23	52	102	148	197	237	268	285	306	320	322	328	335	343	352	360	370	379	387	394	401
80	75	24	53	103	149	199	237	269	286	308	321	328	339	349	358	363	367	372	379	388	395	402
75	99	23	52	102	148	197	237	268	285	306	320	322	328	335	343	352	360	370	379	387	394	401
75	95	26	53	105	151	203	241	274	292	309	323	334	343	352	361	366	373	379	385	390	397	403
75	90	28	54	106	157	204	242	275	295	317	326	340	351	358	364	373	380	386	391	397	403	410
75	80	30	55	108	162	207	245	276	301	317	332	346	355	360	368	375	380	388	396	403	409	413
75	75	31	55	110	162	208	247	277	303	319	333	346	355	360	369	376	383	389	396	403	411	419
50	99	55	70	139	193	241	280	314	339	358	370	383	396	403	411	420	429	438	446	454	460	465
50	95	59	72	145	198	245	287	326	345	365	378	391	401	411	423	433	441	447	458	464	473	477
50	90	61	74	148	201	252	297	327	349	366	381	395	404	414	425	436	443	451	460	467	474	480
50	80	64	75	148	211	263	302	332	355	371	383	400	416	424	433	438	449	455	464	473	479	485
50	75	65	75	148	211	264	305	333	356	373	386	401	417	428	433	440	449	458	465	474	480	486
MEAN (n=137)			84	166	235	293	339	372	395	414	429	442	453	463	473	482	491	500	508	516	524	532
STANDARD DEVIATION			35	69	94	110	119	124	126	128	131	133	135	136	138	140	142	144	146	148	149	151
COEFFICIENT OF VARIATION			42	42	40	38	35	33	32	31	31	30	30	29	29	29	29	29	29	29	29	28
DRY/GREEN RATIO			1.98	2.03	2.05	2.06	2.07	2.09	2.09	2.09	2.08	2.07	2.06	2.05	2.03	2.02	2.00	1.99	1.98	1.98	1.97	1.96

U.S. Forest Products Laboratory.

Mean and tolerance limit stresses and stress modeling for compression perpendicular to grain in hardwood and softwood species; by B. Alan Bendtsen, and William L. Galligan. Madison, Wis., FPL. 15 p. (USDA For. Serv. Res. Pap. FPL 337).

Tables characterize stress-compression relationship of wood in compression perpendicular to grain for several species. Other species can be characterized through selected regression models.

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Tables characterize stress-compression relationship of wood in compression perpendicular to grain for several species. Other species can be characterized through selected regression models.

Table 1. - Mean, standard deviation, coefficient of variation, tolerance limits,¹ and the dry/green ratio for each of 20 compression levels (Engelmann spruce)—continued

Tolerance region Content (Pct. β)	Confidence (Pct. α)	m ²	Compression (in.)																			
			005	010	015	020	025	030	035	040	045	050	055	060	065	070	075	080	085	090	095	100
.95	.90	1	36	72	110	147	182	211	223	232	238	243	248	252	256	260	263	267	271	275	278	282
.95	.80	1	36	72	110	147	182	211	223	232	238	243	248	252	256	260	263	267	271	275	278	282
.95	.75	1	36	72	110	147	182	211	223	232	238	243	248	252	256	260	263	267	271	275	278	282
.90	.99	1	36	72	110	147	182	211	223	232	238	243	248	252	256	260	263	267	271	275	278	282
.95	.95	2	46	94	137	172	196	212	235	255	273	282	288	294	299	304	308	313	318	322	326	329
.90	.90	2	46	94	137	172	196	212	235	255	273	282	288	294	299	304	308	313	318	322	326	329
.90	.80	3	57	117	155	192	220	243	256	268	276	281	289	306	312	318	322	326	329	333	337	340
.90	.75	3	57	117	155	192	220	243	256	268	276	281	289	306	312	318	322	326	329	333	337	340
.80	.99	4	62	127	181	224	248	259	267	275	283	292	304	309	314	318	324	330	336	342	348	354
.95	.95	5	65	131	188	232	261	273	279	285	292	299	305	311	317	323	329	335	341	346	352	357
.80	.90	5	66	131	197	240	267	277	283	287	293	299	305	311	318	324	330	336	341	347	353	359
.80	.80	6	69	132	200	248	269	281	284	289	295	299	309	325	334	339	345	350	354	359	363	367
.80	.80	7	69	132	200	248	269	281	284	289	295	299	309	325	334	339	345	350	354	359	363	367
.80	.75	8	69	142	206	249	271	289	295	303	310	317	324	329	336	344	350	355	361	365	370	374
.75	.99	6	66	131	197	240	267	277	283	287	293	299	305	311	318	324	330	336	341	347	353	359
.75	.95	7	69	132	200	248	269	281	284	289	295	299	309	325	334	339	345	350	354	359	363	367
.75	.90	8	69	142	206	249	271	289	295	303	310	317	324	329	336	344	350	355	361	365	370	374
.75	.80	10	78	154	219	253	278	290	298	307	316	322	328	333	339	345	351	357	362	368	373	378
.75	.75	10	78	154	219	253	278	290	298	307	316	322	328	333	339	345	351	357	362	368	373	378
.50	.99	16	83	164	232	275	292	307	322	330	337	344	352	359	365	372	378	385	390	395	400	405
.50	.95	19	86	172	244	290	306	316	328	335	345	355	363	369	375	381	387	393	399	403	409	414
.50	.90	20	89	172	245	292	309	319	328	339	348	356	364	370	377	383	390	396	403	409	415	421
.50	.80	22	90	176	249	292	311	327	343	349	357	365	373	380	387	395	402	408	415	422	428	434
.50	.75	22	90	176	249	292	311	327	343	349	357	365	373	380	387	395	402	408	415	422	428	434
MEAN (n=49)			93	184	260	306	326	338	349	358	368	377	386	394	402	410	418	425	432	438	445	451
STANDARD DEVIATION			22	42	58	63	61	58	57	58	60	62	64	66	67	70	72	74	75	77	78	79
COEFFICIENT OF VARIATION			24	23	22	21	19	17	16	16	16	16	17	17	17	17	17	17	17	18	18	18
DRY/GREEN RATIO			1.97	2.00	2.00	2.06	2.14	2.16	2.15	2.14	2.13	2.11	2.10	2.09	2.07	2.06	2.05	2.04	2.03	2.03	2.02	2.01

Table 1. - Mean, standard deviation, coefficient of variation, tolerance limits,¹ and the dry/green ratio for each of 20 compression levels (White spruce)—continued

Tolerance region Constant (Pct. B)	Confidence (Pct. a)	m ²	Compression (lb.)																				
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	
95	90	1	57	116	169	203	226	252	270	280	286	290	294	298	302	307	312	316	321	324	328	332	332
95	75	1	57	116	169	203	226	252	270	280	286	290	294	298	302	307	312	316	321	324	328	332	332
90	95	1	57	116	169	203	226	252	270	280	286	290	294	298	302	307	312	316	321	324	328	332	332
90	90	1	57	116	169	203	226	252	270	280	286	290	294	298	302	307	312	316	321	324	328	332	332
90	80	2	61	123	176	212	239	261	277	288	296	304	311	319	325	331	338	344	350	356	362	367	367
90	75	2	61	123	176	212	239	261	277	288	296	304	311	319	325	331	338	344	350	356	362	367	367
80	95	3	63	130	184	213	240	263	283	299	311	320	328	335	343	350	356	362	368	373	379	385	385
80	90	4	69	141	197	222	251	283	305	316	320	325	331	337	344	350	356	362	368	373	379	385	385
80	80	5	71	142	195	225	257	286	307	322	330	337	343	350	356	362	369	375	381	386	392	397	397
80	75	5	71	142	195	225	257	286	307	322	330	337	343	350	356	362	369	375	381	386	392	397	397
75	95	3	63	130	184	213	240	263	283	299	311	320	328	335	343	350	356	362	368	373	379	385	385
75	90	5	71	142	195	225	257	286	307	322	330	337	343	350	356	362	369	375	381	386	392	397	397
75	80	6	71	142	195	225	257	286	307	322	330	337	343	350	356	362	369	375	381	386	392	397	397
75	75	7	72	143	201	231	268	297	316	326	333	342	350	357	363	369	376	382	388	394	400	405	405
50	95	10	76	154	212	252	293	320	346	364	378	386	393	401	408	414	421	428	435	442	449	455	455
50	90	12	76	158	224	270	304	334	359	372	384	393	402	411	420	428	435	442	449	455	461	468	468
50	80	13	82	164	227	279	321	350	384	398	408	417	426	435	444	451	458	464	471	478	483	489	489
50	75	15	85	171	244	293	331	359	376	386	393	402	412	420	428	436	444	451	459	466	473	480	480
50	50	15	85	171	244	293	331	359	376	386	393	402	412	420	428	436	444	451	459	466	473	480	480
MEAN (n = 34)			91	183	258	310	347	372	389	402	412	422	433	442	451	460	469	477	486	493	501	509	509
STANDARD DEVIATION			20	41	58	70	72	70	68	69	71	74	77	79	82	84	87	89	91	93	94	96	96
COEFFICIENT OF VARIATION			22	22	22	23	21	19	17	17	18	18	18	18	18	18	19	19	19	19	19	19	19
DRY/GREEN RATIO			2.19	2.19	2.21	2.25	2.24	2.17	2.12	2.08	2.07	2.05	2.04	2.04	2.03	2.03	2.03	2.02	2.02	2.01	2.00	2.00	2.00

Table 1 - Mean, standard deviation, coefficient of variation, tolerance limits¹ and the dry green ratio for each of 20 compression levels (Northern red oak)---continued

Tolerance Region Content (Pct. β)	Confidence (Pct. α)	m ²	Compression (in.)																			
			0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	
96	80	1	53	117	162	213	262	303	340	360	381	400	421	440	460	478	495	511	527	545	557	
96	75	1	53	117	162	213	262	303	340	360	381	400	421	440	460	478	495	511	527	545	557	
95	99	3	73	179	222	290	359	394	419	438	455	468	481	494	506	519	531	541	550	558	574	
95	95	5	86	189	236	309	362	420	434	446	462	467	476	480	477	497	509	521	533	546	574	
95	90	6	92	197	290	341	397	423	478	514	529	544	558	572	584	604	621	633	643	653	675	
95	80	7	94	204	301	375	415	458	494	516	533	550	566	582	597	611	622	634	645	656	675	
95	75	7	94	204	301	375	415	458	494	516	533	550	566	582	597	611	622	634	645	656	675	
90	99	10	107	225	336	400	466	509	546	565	580	631	662	674	685	698	709	719	729	737	754	
90	95	12	115	233	343	440	502	551	581	623	638	650	711	701	714	727	739	750	760	769	786	
90	90	13	118	242	345	441	509	564	596	626	646	667	685	701	722	738	750	760	771	783	812	
90	80	15	119	244	349	459	544	588	611	636	666	688	706	723	737	753	766	785	798	810	828	
90	75	15	122	244	349	460	544	596	612	639	667	697	713	729	745	762	773	790	806	818	835	
90	99	25	135	262	374	479	571	633	677	713	730	745	767	789	809	825	837	847	859	872	888	
90	95	28	138	275	402	508	573	653	702	728	753	779	797	807	824	846	865	879	894	913	946	
90	90	30	140	279	407	521	581	659	705	733	762	780	797	818	836	856	873	892	915	925	957	
90	80	32	140	287	409	524	591	674	707	742	774	796	814	840	858	878	899	915	930	945	960	
90	75	33	141	287	409	530	595	675	707	746	779	808	829	845	865	884	899	919	938	954	992	
75	99	33	141	287	409	530	595	675	707	746	779	808	829	845	865	884	899	919	938	954	992	
75	95	37	144	293	422	542	622	686	717	756	809	839	859	876	895	911	923	940	956	970	1009	
75	90	39	147	297	428	548	641	697	740	777	823	855	869	886	920	943	962	978	993	1008	1040	
75	80	41	148	304	443	556	646	699	755	796	832	861	897	928	942	955	975	992	1003	1015	1060	
75	75	42	149	306	443	562	652	699	766	791	833	872	899	932	952	973	989	1007	1027	1045	1073	
50	99	77	188	378	539	679	783	862	921	966	1000	1028	1052	1070	1094	1115	1131	1151	1164	1205	1218	
50	95	81	191	384	558	704	801	870	932	981	1009	1038	1062	1081	1102	1131	1151	1169	1184	1204	1233	
50	90	84	192	391	567	710	803	874	939	982	1021	1047	1075	1091	1116	1137	1156	1174	1190	1206	1246	
50	80	87	195	401	586	717	806	882	943	986	1027	1051	1077	1101	1121	1139	1165	1183	1198	1215	1253	
50	75	88	196	411	589	721	808	885	946	993	1029	1052	1079	1102	1121	1143	1167	1188	1202	1219	1254	
MEAN (n=185)			216	424	584	723	819	897	946	987	1021	1052	1080	1106	1128	1153	1175	1195	1211	1229	1258	1277
STANDARD DEVIATION			96	144	169	196	213	226	234	241	247	253	259	264	268	274	280	285	288	292	327	325
COEFFICIENT OF VARIATION			40	34	29	27	26	25	25	24	24	24	24	24	24	24	24	24	24	24	24	25
DRY/GREEN RATIO			2.42	1.95	1.76	1.66	1.62	1.60	1.59	1.58	1.57	1.57	1.56	1.56	1.56	1.56	1.56	1.54	1.56	1.56	1.50	1.51

Table 1. - Mean, standard deviation, coefficient of variation, tolerance limits,¹ and the dry/green ratio for each of 28 compression levels (quoting ages) - continued

Tolerance region Content (P-ct. B)	Confidence (F t. α)	m ²	Compression (in.)																											
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00								
95	75	1	25	50	72	94	115	137	161	184	202	215	224	228	229	230	233	238	245	253	262	272								
90	90	1	25	50	72	94	115	137	161	184	202	215	224	228	229	230	233	238	245	253	262	272								
90	80	1	25	50	72	94	115	137	161	184	202	215	224	228	229	230	233	238	245	253	262	272								
90	75	2	29	57	82	108	133	156	184	201	212	219	224	229	234	241	247	253	259	265	271	276								
90	95	1	25	50	72	94	115	137	161	184	202	215	224	228	229	230	233	238	245	253	262	272								
90	95	2	29	57	82	108	133	156	184	201	212	219	224	229	234	241	247	253	259	265	271	276								
90	90	3	31	61	91	123	154	186	194	206	218	230	243	254	266	277	284	290	297	304	311	316								
90	80	4	32	67	98	129	160	186	213	229	239	250	259	266	271	277	286	295	300	306	311	316								
90	75	4	32	67	98	129	160	186	213	229	239	250	259	266	271	277	286	295	300	306	311	316								
75	95	2	29	57	82	108	133	156	184	201	212	219	224	229	234	241	247	253	259	265	271	276								
75	95	3	31	61	91	123	154	186	194	206	218	230	243	254	266	277	284	290	297	304	311	316								
75	90	4	32	67	98	129	160	186	213	229	239	250	259	266	271	277	286	295	300	306	311	316								
75	80	5	34	68	100	133	165	190	214	232	245	254	260	267	275	282	289	296	302	309	317	322								
75	75	5	34	68	100	133	165	190	214	232	245	254	260	267	275	282	289	296	302	309	317	322								
50	99	8	39	77	116	153	190	210	230	252	264	272	286	292	296	299	304	311	319	328	338	345								
50	95	10	41	82	119	154	192	218	237	256	268	278	287	296	301	306	311	316	323	333	341	350								
50	90	11	43	86	131	166	193	222	239	256	270	281	289	297	306	314	321	327	332	338	346	351								
50	80	12	45	89	132	169	194	223	242	260	273	282	291	302	314	320	324	329	336	343	349	353								
50	75	12	45	89	132	169	194	223	242	260	273	282	291	302	314	320	324	329	336	343	349	353								
MEAN (n = 28)			48	94	138	180	209	234	254	272	286	299	308	315	322	328	334	340	346	353	360	367								
STANDARD DEVIATION			12	23	34	41	41	41	40	41	43	45	48	51	52	53	54	53	53	53	53	53								
COEFFICIENT OF VARIATION			25	24	25	23	20	18	16	15	15	15	16	16	16	16	16	16	16	15	15	14								
DRY/GREEN RATIO			2.52	2.69	2.84	2.75	2.91	2.83	2.79	2.73	2.68	2.66	2.66	2.66	2.64	2.62	2.58	2.55	2.53	2.51	2.50	2.49								

¹Mean, standard deviation, and tolerance limits are in lb./in.²; coefficient of variation is percent.
²Are a percent confident that B percent of the population sampled is the given smallest observation.
³In an effort to reduce the large amount of computation required for table 1, no interior North Douglas-fir air dry specimens were included in the analysis. It is assumed that the dry/green ratios for Coast Douglas-fir apply to Douglas-fir from all geographic regions.

Table 2.—Statistics for the regression model $\log y = A + B \log x$ where y is either the mean or a tolerance limit stress (lb./in.²) and x is an average D 2555 modulus of elasticity value for a species

Regression No.	Tolerance limit		Confidence	Compression	Regression coefficients		r ²	n	Residual mean-square	$\frac{1}{\log x}$	log Σy^2
	Pct	Tolerance region			A	B					
TOLERANCE LIMIT VERSUS MODULUS OF ELASTICITY											
1	95		75	0.02	-0.5975 + 0.1	0.1352 + 0.1	0.402	9	0.2086 - 0.1	0.6099 + 0.1	0.3348 + 0.3
2	95		75	.04	-4.775 + 0.1	1.189 + 0.1	504	9	1.069 - 0.1	6.099 + 0.1	3348 + 0.3
3	95		75	.06	-4.616 + 0.1	1.173 + 0.1	507	9	1.028 - 0.1	6.099 + 0.1	3348 + 0.3
4	95		75	.08	-5.003 + 0.1	1.241 + 0.1	550	9	9.671 - 0.2	6.099 + 0.1	3348 + 0.3
5	95		75	.10	-4.472 + 0.1	1.159 + 0.1	506	9	1.005 - 0.1	6.099 + 0.1	3348 + 0.3
6	95		95	.02	28.11 + 0.1	-8.444 - 0.1	000	6	3.574 - 0.1	6.147 + 0.1	2267 + 0.3
7	95		95	.04	9.994 + 0.0	2.592 + 0.0	003	6	2.219 - 0.1	6.147 + 0.1	2267 + 0.3
8	95		95	.06	1.201 + 0.1	2.247 + 0.0	002	6	1.820 - 0.1	6.147 + 0.1	2267 + 0.3
9	95		95	.08	1.372 + 0.1	2.030 + 0.0	002	6	1.831 - 0.1	6.147 + 0.1	2267 + 0.3
10	95		95	.10	1.607 + 0.1	1.693 + 0.0	001	6	1.853 - 0.1	6.147 + 0.1	2267 + 0.3
11	75		75	.02	-6.792 + 0.1	1.513 + 0.1	467	9	2.003 - 0.1	6.099 + 0.1	3348 + 0.3
12	75		75	.04	-6.024 + 0.1	1.414 + 0.1	502	9	1.520 - 0.1	6.099 + 0.1	3348 + 0.3
13	75		75	.06	-5.985 + 0.1	1.416 + 0.1	487	9	1.620 - 0.1	6.099 + 0.1	3348 + 0.3
14	75		75	.08	-5.650 + 0.1	1.366 + 0.1	466	9	1.639 - 0.1	6.099 + 0.1	3348 + 0.3
15	75		75	.10	-5.411 + 0.1	1.332 + 0.1	454	9	1.636 - 0.1	6.099 + 0.1	3348 + 0.3
16	75		95	.02	-7.172 + 0.1	1.673 + 0.1	481	9	2.050 - 0.1	6.099 + 0.1	3348 + 0.3
17	75		95	.04	-6.928 + 0.1	1.560 + 0.1	555	9	1.496 - 0.1	6.099 + 0.1	3348 + 0.3
18	75		95	.06	-6.169 + 0.1	1.444 + 0.1	518	9	1.489 - 0.1	6.099 + 0.1	3348 + 0.3
19	75		95	.08	-5.588 + 0.1	1.354 + 0.1	488	9	1.475 - 0.1	6.099 + 0.1	3348 + 0.3
20	75		95	.10	-5.346 + 0.1	1.319 + 0.1	466	9	1.527 - 0.1	6.099 + 0.1	3348 + 0.3
21	50		75	0.02	-0.7613 + 0.1	0.1655 + 0.1	0.507	9	0.1906 - 0.1	0.6099 + 0.1	0.3348 + 0.3
22	50		75	.04	-1.182 + 0.1	0.1617 + 0.1	546	9	1.671 - 0.1	6.099 + 0.1	3348 + 0.3
23	50		75	.06	-6.783 + 0.1	1.559 + 0.1	536	9	1.614 - 0.1	6.099 + 0.1	3348 + 0.3
24	50		75	.08	-6.656 + 0.1	1.527 + 0.1	525	9	1.621 - 0.1	6.099 + 0.1	3348 + 0.3
25	50		75	.10	-6.374 + 0.1	1.501 + 0.1	519	9	1.605 - 0.1	6.099 + 0.1	3348 + 0.3
26	50		95	.02	-7.614 + 0.1	1.663 + 0.1	504	9	2.091 - 0.1	6.099 + 0.1	3348 + 0.3
27	50		95	.04	-7.235 + 0.1	1.624 + 0.1	537	9	1.741 - 0.1	6.099 + 0.1	3348 + 0.3
28	50		95	.06	-6.828 + 0.1	1.565 + 0.1	529	9	1.674 - 0.1	6.099 + 0.1	3348 + 0.3
29	50		95	.08	-6.849 + 0.1	1.573 + 0.1	536	9	1.647 - 0.1	6.099 + 0.1	3348 + 0.3
30	50		95	.10	-6.456 + 0.1	1.513 + 0.1	518	9	1.631 - 0.1	6.099 + 0.1	3348 + 0.3
MEAN VERSUS MODULUS OF ELASTICITY											
31		MEAN		.02	-7.477 + 0.1	1.647 + 0.1	569	9	1.574 - 0.1	6.099 + 0.1	3348 + 0.3
32		do		.04	-7.195 + 0.1	1.622 + 0.1	598	9	1.355 - 0.1	6.099 + 0.1	3348 + 0.3
33		do		.06	-6.805 + 0.1	1.566 + 0.1	581	9	1.359 - 0.1	6.099 + 0.1	3348 + 0.3
34		do		.08	-6.662 + 0.1	1.551 + 0.1	576	9	1.360 - 0.1	6.099 + 0.1	3348 + 0.3
35		do		.10	-6.428 + 0.1	1.514 + 0.1	561	9	1.377 - 0.1	6.099 + 0.1	3348 + 0.3

Table 3.—Statistics for the regression model $y = A + Bx$ where y is either the mean or a tolerance limit stress (lb/in.²) and x is an average D 2555 specific gravity value for a species

Regression No.	Tolerance limit		Confidence	Compression level	Regression coefficients		r ²	n	Residual mean square	s	Σ x ²
	Pct	Tolerance region			A	B					
TOLERANCE LIMIT VERSUS SPECIFIC GRAVITY											
1	95	0.02	75	0.02	-0.1551 + 03	0.8721 + 03	0.652	9	0.2751 + 04	0.4069 + 00	0.1537 + 01
2	95	04	75	04	-1.569 + 03	1.158 + 04	.752	9	2994 + 04	4069 + 00	.1537 + 01
3	95	06	75	06	-1.857 + 03	1.341 + 04	.785	9	3337 + 04	4069 + 00	.1537 + 01
4	95	08	75	08	-2.138 + 03	1.476 + 04	.803	9	3625 + 04	4069 + 00	.1537 + 01
5	95	10	75	10	-2.211 + 03	1.560 + 04	.805	9	3987 + 04	4069 + 00	.1537 + 01
6	95	02	95	02	-2.245 + 03	1.001 + 04	.746	6	2060 + 04	4425 + 00	.1199 + 01
7	95	04	95	04	-1.346 + 03	1.050 + 04	6.15	6	4152 + 04	4425 + 00	.1199 + 01
8	95	06	95	06	-1.696 + 03	1.274 + 04	.700	6	4186 + 04	4425 + 00	.1199 + 01
9	95	08	95	08	-2.146 + 03	1.457 + 04	.708	6	5214 + 04	4425 + 00	.1199 + 01
10	95	10	95	10	-2.553 + 03	1.615 + 04	.732	6	5737 + 04	4425 + 00	.1199 + 01
11	75	02	75	02	-2.855 + 03	1.427 + 04	.743	9	4764 + 04	4069 + 00	.1537 + 01
12	75	04	75	04	-4.072 + 03	2.048 + 04	.830	9	5802 + 04	4069 + 00	.1537 + 01
13	75	06	75	06	-5.174 + 03	2.453 + 04	.854	9	6997 + 04	4069 + 00	.1537 + 01
14	75	08	75	08	-5.573 + 03	2.639 + 04	.859	9	7756 + 04	4069 + 00	.1537 + 01
15	75	10	75	10	-5.859 + 03	2.789 + 04	.854	9	8980 + 04	4069 + 00	.1537 + 01
16	75	02	95	02	-2.741 + 03	1.375 + 04	.727	9	4804 + 04	4069 + 00	.1537 + 01
17	75	04	95	04	-4.083 + 03	2.017 + 04	.825	9	5842 + 04	4069 + 00	.1537 + 01
18	75	06	95	06	-4.688 + 03	2.297 + 04	.856	9	6010 + 04	4069 + 00	.1537 + 01
19	75	08	95	08	-4.888 + 03	2.434 + 04	.862	9	6402 + 04	4069 + 00	.1537 + 01
20	75	10	95	10	-5.280 + 03	2.605 + 04	.860	9	7501 + 04	4069 + 00	.1537 + 01
21	50	0.02	75	0.02	-4.130 + 03	0.1947 + 04	0.796	9	0.6990 + 04	0.4069 + 00	0.1537 + 01
22	50	04	75	04	-5.974 + 03	2.743 + 04	.861	9	8222 + 04	4069 + 00	.1537 + 01
23	50	06	75	06	-6.560 + 03	3.016 + 04	.871	9	9114 + 04	4069 + 00	.1537 + 01
24	50	08	75	08	-7.044 + 03	3.236 + 04	.875	9	1017 + 05	4069 + 00	.1537 + 01
25	50	10	75	10	-7.315 + 03	3.393 + 04	.870	9	1162 + 05	4069 + 00	.1537 + 01
26	50	02	95	02	-4.181 + 03	1.932 + 04	.784	9	6961 + 04	4069 + 00	.1537 + 01
27	50	04	95	04	-6.051 + 03	2.729 + 04	.859	9	8238 + 04	4069 + 00	.1537 + 01
28	50	06	95	06	-6.535 + 03	2.981 + 04	.870	9	8998 + 04	4069 + 00	.1537 + 01
29	50	08	95	08	-7.076 + 03	3.214 + 04	.873	9	1020 + 05	4069 + 00	.1537 + 01
30	50	10	95	10	-7.322 + 03	3.361 + 04	.874	9	1103 + 05	4069 + 00	.1537 + 01
MEAN VERSUS SPECIFIC GRAVITY											
31											
32	MEAN	02			-3.770 + 03	1.902 + 04	.786	9	6677 + 04	4069 + 00	.1537 + 01
33	do	04			-5.513 + 03	2.674 + 04	.870	9	7238 + 04	4069 + 00	.1537 + 01
34	do	06			-6.197 + 03	2.990 + 04	.888	9	7645 + 04	4069 + 00	.1537 + 01
35	do	08			-6.659 + 03	3.211 + 04	.887	9	8925 + 04	4069 + 00	.1537 + 01
	do	10			-7.057 + 03	3.403 + 04	.885	9	1016 + 05	4069 + 00	.1537 + 01