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SHRINKAGE ALLOWANCES FOR LUMBER SAWN TO MEET SPECIFIED SIZES

by

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June, 1988

Project No.: 02-12-43-K-205

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SUMMARY

Softwood lumber exported to the U.K. for use in construction is subject to specifications regarding moisture content and size. A matter of concern is whether green lumber sawn to a bare minimum to maximize output will shrink to an extent that it does not meet in-service requirements. Two studies were carried out using published shrinkage values and actual wood samples to predict the extent of the problem. Both studies demonstrated that particularly when the range of values, not just average, is considered the requirements of the U.K. Standard will not be met. This could have serious implications for green softwood lumber in the U.K. marketplace.

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1.0 OBJECTIVES

This study sought to determine whether British Columbia (B.C.) mills are at risk in the United Kingdom (U.K.) market due to current sawing practices.

2.0 INTRODUCTION

Softwood lumber exported to the U.K. for use in construction is subject to specifications relating to moisture content and size. The applicable standard is BS4471:1987 entitled British Standard Specifications for Sizes of Sawn and Processed Softwood.

The Standard includes a table of basic sizes which are to be met when the wood moisture content (MC) is 20%. This does not preclude supplying and using green wood provided that it can be shown that it will be on size at 20% MC. The following statements provide permitted deviations:

4.2.1 Cross section. Not more than 10% of the pieces in any parcel of sawn softwood shall have minus deviations.

4.2.2 Thicknesses and widths. In thicknesses and widths not exceeding 100 mm, the maximum permitted deviations shall be -1 mm, +3 mm. In thicknesses and widths over 100 mm, the maximum permitted deviations shall be -2 mm, +6 mm.

The bulk of the green lumber sent to the U.K. is $1\frac{7}{8}$ x 4,6,8,10 and 12 in. There it is resold and classified as 47 x 100, 150, 200, 250 and 300 mm. The Council of Forest Industries (COFI) recently asked Forintek to determine whether $1\frac{7}{8}$ in. or 47.625 mm x (for example) 8 in. or 203.2 mm is sufficient to meet the requirements of BS4471 which in this case would be 47 x 200 mm at 20% MC. Should this lumber shrink to less than the required sizes, smaller span tolerances would be applied. This would result in Canadian lumber losing competitiveness with other material, for example from Scandinavia, that is supplied full size after drying to about 20% MC. The B.C. industry therefore faces a conflict between sawing to a bare minimum to maximize yield or recovery but losing markets due to under-allowance for shrinkage.

3.0 APPROACH

The ideal way to address this concern is to obtain quantities of the lumber in question, allow it to equilibrate to 20% MC, and determine whether it is on size. This approach is however both technically difficult with large size material, and very time consuming. Since a response to COFI was required with some urgency two alternative methods were applied. In the first a "paper" study was carried out using standard shrinkage values to calculate sizes at 20% MC. This was followed by a second study where green wood samples were measured,

oven-dried and remeasured to provide actual shrinkage values to 0% MC and calculation of shrinkage to 20% MC.

4.0 STAFF

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5.0 PROCEDURES

5.1 CALCULATED SIZES

The example used was green hemlock sawn $1\frac{7}{8}$ x 8 in., that is 47.625 x 203.2 mm. Shrinkage values used were from Forintek Publication SP-24R[1]. These values are tangential shrinkage 8.5% and radial shrinkage 5.4%, both at 0% MC. Fiber saturation point is assumed to be 27% MC. In drying to 20% MC the amount of shrinkage is 27-20/27 or 7/27 of the above values. Thus tangential shrinkage is 2.2% and radial shrinkage is 1.4%.

5.2 MEASURED SIZES

Fifty, 4 ft. lengths each of 2 x 4, 8, and 10 green hem-fir and 50, 4 ft. lengths each of 2 x 4, 8 and 12 green white spruce were supplied by COFI and COFI/NILS respectively. Each length was treated as is shown in Figure 1. The end few inches of each piece were discarded. Sections A and B, measuring about 2 in. along the grain were measured for green weight, volume (by displacement), and width and thickness. Each was then oven-dried to 0% MC, and remeasured for weight, width and thickness. Calculations of green moisture content, specific gravity and width and thickness shrinkages were then made.

With the remaining 3 ft. (approximate) lengths, green weight was measured, as was width and thickness at a marked position mid-length but free of knots or other defects. All pieces were placed in a kiln to dry slowly with minimum degrade and finally oven-dried at 215°F. Weight, width and thickness were then remeasured, and shrinkage was calculated.

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[1] Nielson, R.W., J. Dobie and D.M. Wright. 1985. Conversion Factors for the Forest Products Industry in Western Canada. Forintek Special Publication No. SP-24R. 92p.

6.0 RESULTS AND DISCUSSION

6.1 CALCULATED SIZES

(a) Assume flatsawn board:

Thickness: Green size = 47.625 mm
Shrinkage to 20% MC = 47.625 x 1.4 % = 0.667 mm
Size at 20% MC = 46.96 mm (undersize)

Width: Green Size = 203.2 mm
Shrinkage to 20% MC = 203.2 x 2.2% = 4.47 mm
Size at 20% MC = 198.73 mm (undersize)

(b) Assume edgesawn board:

Thickness: Green size = 4.7625 mm
Shrinkage to 20% MC = 47.625 x 2.2% = 1.05 mm
Size at 20% MC = 46.575 mm (undersize)

Width: Green size = 203.2 mm
Shrinkage to 20% MC = 2.84 mm
Size at 20% MC = 200.36 mm (on size)

These calculations show that if the assumptions are correct, on average thickness will always be undersize irrespective of grain angle, but by not more than the maximum permitted, 1 mm. Width of flatsawn boards will also be undersize but by less than the permitted 2 mm. Since BS4471 allows only 10% of pieces to have any minus deviation, hemlock producers are clearly at considerable risk by sawing to the above green sizes. Similar calculations for other major western softwoods using the same source data for shrinkage show that all edgesawn pieces fail to conform in thickness and all flatsawn pieces fail to conform in width.

A shortcoming of this approach is that it uses average shrinkage values only. Thus it could be argued that assuming normal distribution, half of the pieces would shrink less than the average. Equally however, half will shrink by more than the average, thus some pieces may fail BS4471 outright by shrinking more than the permitted maximum tolerances. Furthermore these calculations cannot be readily applied to pieces with mixed grain. To address these points in part a second study based on actual measured shrinkage was requested.

6.2 MEASURED SIZES

Table 1 presents average green moisture content and specific gravity values calculated from measurements on Sections A and B. These values are consistent with averages for the species cited in standard reference tests. Shrinkage values for the 3 ft. lengths are shown in Table 2. These values do not differ markedly from shrinkages measured with the small sections, nor was there any consistent trend of sections shrinking more or less than the corresponding board from which they were sawn.

The data in Table 2 should be interpreted as follows. If green boards sawn to a thickness of 47.625 mm shrink to 47.0 mm at 20% MC, shrinkage of 1.312% has occurred. Assuming a fiber saturation point of 27% MC, total shrinkage to 0% MC would therefore be:

$$1.312 \times 27/7 = 5.06\%$$

Any thickness shrinkage greater than 5.06% would therefore result in lumber failing to comply with BS4471 in this regard.

From Table 2 it is apparent that on average only hem-fir 2 x 10s exceed this limit in thickness shrinkage. When just one standard deviation added to the average is considered however, all groups except the 2 x 4s shrink in excess of the maximum permitted. Since the average plus and minus one standard deviation covers about 68% of a population, it is clear that more than 10% will shrink in excess of the maximum permitted. The data of Table 3 further underscores this point.

Table 3 shows the number of boards in each group of 50 that shrank in excess of the maximum permitted in width and shrinkage by BS4471. It has been shown earlier that maximum shrinkage allowed is 5.06%. If it is assumed that green sawn widths are full 4, 8 10 and 12 in. i.e., 101.6, 203.2, 254 and 304.8 mm respectively, to produce U.K. sizes of 100, 200, 250 and 300 mm width at 20% MC, it can be similarly calculated that in each case shrinkage to 20% MC is 1.575% and therefore to 0% MC is 6.075%. In the present test with 50 boards in each species/size group the number that exceeded these shrinkage limits are shown. Any number over 5, i.e., 10%, exceeds BS4471. Thus in either thickness, width, or both all species/size groups failed to comply.

The values shown in Table 2 can also be used to obtain an estimate of green sizes that would be required to provide shrinkage allowances sufficient to allow almost all pieces to meet BS4471. These green sizes, shown in Tables 4 and 5, were calculated based on the consideration that the average plus and minus three standard deviations contains 99.74% of the total sample.

7.0 CONCLUSIONS

Green sawn sizes of $1\frac{7}{8}$ by 4, 8, 10 and 12 in. provide insufficient allowance for shrinkage when this lumber is later reclassified into metric sizes at 20% MC of 47 by 100, 200, 250 and 300 mm respectively, as required by BS4471. This conclusion is based on both a theoretical study using published shrinkage values, and actual shrinkage tests on cross-sections of the sizes in question. Further calculations show that thickness and width increases of up to 1 and 3 mm respectively would provide virtually total coverage of all normal shrinkage to 20% MC.

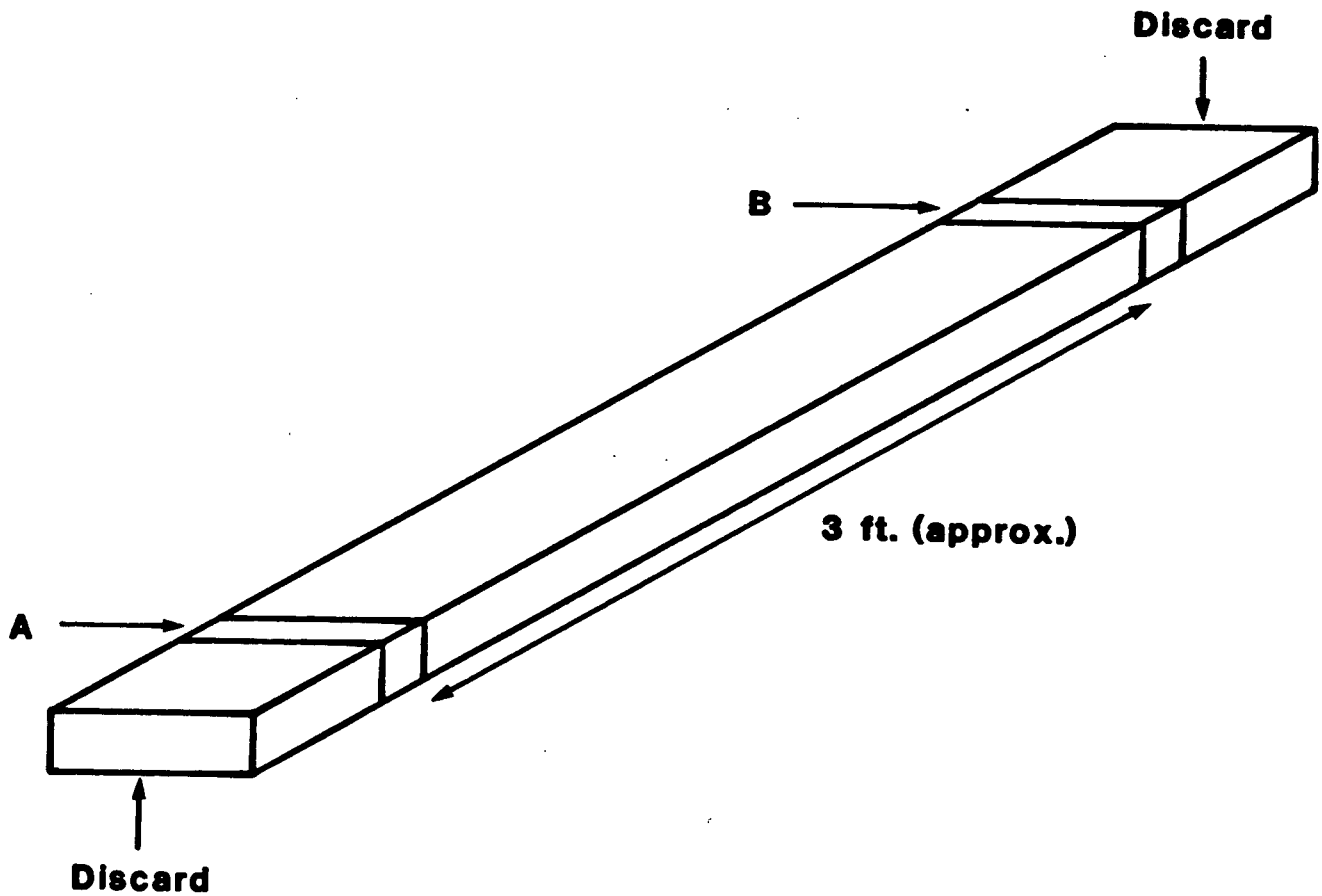

Figure 1. Specimen preparations for moisture content, specific gravity and shrinkage measurements.

Table 5

Green target widths required for over 99% of pieces to meet the BS4471 requirements at 20% MC

Species/Size	Shrinkage % to 20% MC[1]	Size at 20% MC (mm)	Required Green Size (mm)
Hem-fir 2x4	2.610	100	102.68
2x8	2.825	200	205.82
2x10	2.167	250	255.54
Spruce 2x4	2.268	100	102.32
2x8	2.115	200	204.32
2x12	1.975	300	306.04

[1] Calculated from Table 2, average plus 3 standard deviations

Table 3

Number of boards out of 50 in each species/size group that shrank more than the maximum permitted by BS4471:1987

Species/Size	No. of Boards with excess shrinkage	
	Width	Thickness
Hem-fir		
2 x 4	24	1
2 x 8	31	21
2 x 10	9	28
Spruce		
2 x 4	17	3
2 x 8	9	12
2 x 12	0	18

Assumptions:

1. Green lumber sawn $1\frac{7}{8}$ x full width of 4, 8, 10 and 12 in.
2. Fiber saturation point is 27% MC.

Table 4

Green target thicknesses required for almost all pieces to meet the BS4471 requirement of 47 mm at 20% MC

Species/Size	Shrinkage % to 20% MC[1]	Green thickness (mm)
Hem-fir 2x4	1.530	47.73
2x8	2.252	48.09
2x10	2.610	48.26
Spruce 2x4	1.769	47.85
2x8	2.058	47.99
2x12	2.046	47.98

[1] Calculated from Table 2, average plus 3 standard deviations

Table 1

Average green moisture contents and specific gravities for hem-fir and white spruce sections A and B

Species/Size	Moisture Content (%)	Specific Gravity
Hem-fir 2 x 4	80.8	0.409
2 x 8	82.6	0.423
2 x 10	56.1	0.396
Spruce 2 x 4	54.0	0.346
2 x 8	44.4	0.352
2 x 12	38.1	0.327

Table 2

Shrinkage in width and thickness from green to 0% MC of each species/size group of 50 boards

Species/Size Dimension	Shrinkage %			
	Average	Standard Deviation	Minimum	Maximum
Hem-fir 2x4				
Width	5.891	1.392	2.879	8.510
Thickness	3.251	0.883	1.641	5.864
Hem-fir 2x8				
Width	6.371	1.509	3.335	9.379
Thickness	4.754	1.311	2.075	8.631
Hem-fir 2x10				
Width	4.910	1.150	2.970	7.369
Thickness	5.256	1.604	1.746	8.349
Spruce 2x4				
Width	5.441	1.102	2.473	8.076
Thickness	3.085	1.246	1.001	7.354
Spruce 2x8				
Width	5.003	1.051	2.773	6.671
Thickness	4.361	1.192	2.132	7.077
Spruce 2x12				
Width	4.563	1.018	2.069	6.079
Thickness	4.701	1.064	2.427	6.850