Effect of Freezing Temperature on Stress Wave Speed of Green Ponderosa Pine Boards

By

Xiping Wang, Research Associate
Robert J. Ross, Project Leader

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Carter Harvey Holt Ltd.
Private Bag 92-106
Aukland, New Zealand

Natural Resources Research Institute
University of Minnesota Duluth
5013 Miller Trunk Highway
Duluth, Minnesota, 55811

OBJECTIVE

The purpose of this pilot study was to investigate the effect of freezing temperature on stress wave measures of green ponderosa pine boards and to quantify the relationship between stress wave speeds of green boards measured at room temperature and freezing temperature. This study was conducted under a service agreement between the Natural Resources Research Institute (NRRI) at the University of Minnesota Duluth and CHH Fibre-Gen Inc.

MATERIALS AND METHOD

Fifty 8.5 ft (2.59 m-long) 2- by 4-in (51- by 102-mm) green ponderosa pine boards were randomly selected from a lumber stack that was stored at a local commercial cold storage room. The boards have been evaluated using a longitudinal stress wave method at room temperature (approximately 60°F/15.6°C) at the USDA Forest Products Laboratory before being transported to the cold room. The estimated moisture content of the green boards was 115 percent based on the oven test of moisture samples.

The same longitudinal stress wave method was then used to measure stress wave speed on selected green ponderosa pine boards at a freezing temperature condition. The temperature of the storage room where the boards were stored was -1°F/-18.3°C. The boards had been stored there for approximately one month by the time of conducting the stress wave testing. We assume that the temperature of the boards has reached -1°F/-18.3°C by that time. Due to the freezing effect, a certain amount of water near the board surface moved out in some boards and formed a thin ice layer on the surface. We think the moisture loss in the boards due to this effect was minor.

RESULTS

The stress wave speeds of green ponderosa pine boards measured at both room temperature and cold temperature conditions are tabulated in Table 1. Table 2 summarizes the statistics of stress wave speeds at two temperature conditions. Figure 1 shows the distribution of stress wave speed at two temperature conditions.

A significant stress wave speed increase was observed on green ponderosa pine boards as the temperature of the boards decreased from 60°F/15.6°C to -1°F/-18.3°C. The stress wave speeds of the boards ranged from 1367 to 2978 m/s at room temperature condition and from 2555 to 3833 m/s at the freezing temperature condition. The stress wave speed measured at freezing temperature increased approximately 49 percent in average compared to that measured at room temperature condition.

Despite the significant difference in stress wave speed values for two test conditions, a strong linear relationship was found between stress wave speed measured at freezing temperature (C_{FT}) and stress wave speed measured at room temperature (C_{RT}) (Figure 2). The correlation of determination was 0.82.

CONCLUSIONS AND RECOMMENDATIONS

The results from this pilot study showed that freezing temperature has a significant effect on stress wave measures of green wood. As temperature drops to freezing temperature, an increase

in stress wave speed would be expected. The linear relationship between stress wave speeds measured at room and freezing temperature conditions was found to be strong, indicating that an appropriate adjustment can be made on stress wave measures for compensating cold temperature effect when stress wave tests are performed at freezing weather conditions.

The data collected from this study are limited to two temperature conditions: 60°F and -1°F. We speculate that the temperature effect might be different at different temperature regions (above 32°F/0°C and below 32°F/0°C) because of the fact that waves travel at different speeds in water and ice (1450 m/s in water and 3200 m/s in ice). A broad data base on stress wave speed at a series of temperature conditions (from room temperature to freezing winter temperature) would help to further understand the effect of cold temperature on stress wave measures of green wood materials.

Table 1.--Stress wave speeds of ponderosa pine boards 2- by 4s measured at room temperature and freezing temperature conditions.[1]

Test No.	Board No.	Stress Wave Speed of Boards - C (m/s) C_{RT} (room temperature: 60°F)	C_{FT} (freezing temperature: -1°F)
1	1193	2399	3473
2	1218	1677	2841
3	1229	2081	3034
4	1232	2324	3305
5	1239	1912	2985
6	1240	2863	3464
7	1131	2467	3271
8	1089	1739	3092
9	1062	2040	3129
10	1148	2444	3356
11	1066	1716	2762
12	1012	1884	3199
13	1147	2313	3206
14	1013	1781	2792
15	1144	2410	3473
16	1093	2177	3313
17	1018	1864	2971
18	1159	1629	2774
19	947	2124	3062
20	942	2224	3400
21	725	1799	2780
22	732	1604	2762
23	638	2098	3152
24	625	1645	2835
25	806	2467	3271
26	803	2433	3427
27	1091	2243	3144
28	1025	1456	2699
29	960	2150	3006
30	826	1905	3129
31	636	2293	3206
32	745	1682	2716
33	1152	2205	3199
34	1109	2479	3230
35	1032	1447	2591
36	959	1699	2596
37	828	1831	2612
38	632	2253	3206
39	796	2553	3339
40	1244	2644	3598
41	1190	2106	2992
42	1120	2106	3214
43	1035	1775	3006
44	649	1367	2555
45	834	1781	2804
46	956	2456	3482
47	792	2303	2985
48	160	2444	3482
49	144	1963	3152
50	341	2978	3833

[1]Estimated moisture content of green boards: 115%

Table 2.--Statistics of stress wave speeds of green ponderosa pine 2- by 4s measured at room temperature and freezing temperature conditions.[1]

Test condition	Number of Samples	Stress Wave Speed C (m/s)			
		Mean	Standard Deviation	Min.	Max.
Room temperature (60°F)	50	2085	369.3	1367	2978
Freezing temperature (-1°F)	50	3098	294.1	2555	3833

[1]Estimated moisture content of green boards: 115%

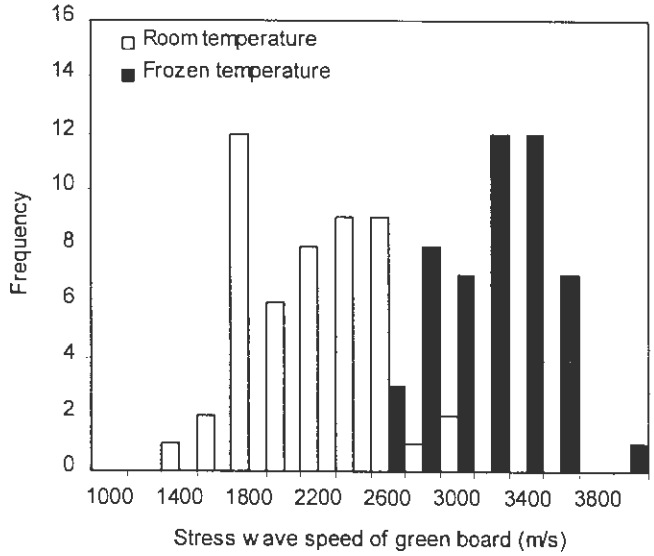

Figure 1.--Distribution of stress wave speed of green ponderosa pine boards.

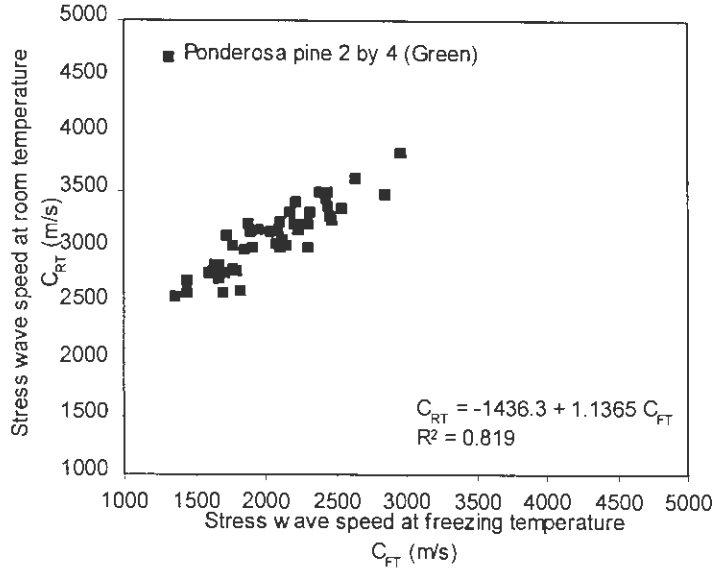

Figure 2.--Relationship between stress wave speeds of green ponderosa pine boards measured at room and freezing temperature conditions.