TechLine

Forest Products Laboratory

Temperature Adjustments Increase Accuracy of Grade Assignments

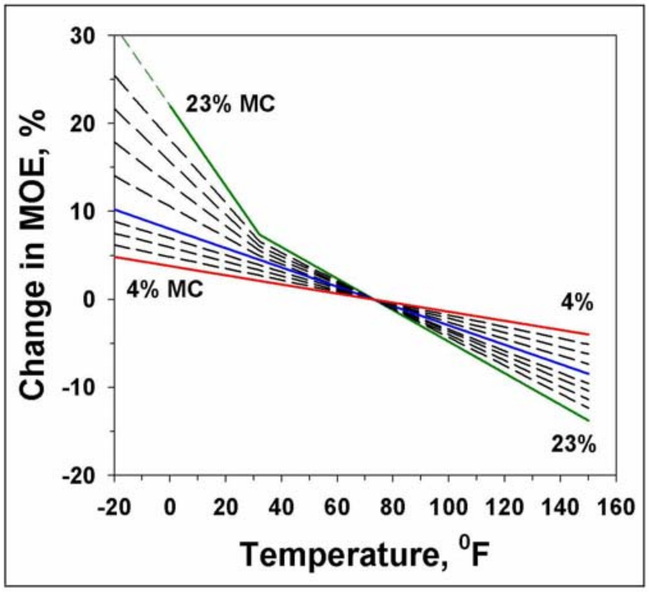

Figure 1— How change in temperature affects modulus of elasticity (MOE) of 2 by 4s.

Changes in moisture content and temperature can cause large changes in the mechanical properties of wood. Historically, tests of wood properties were conducted in a laboratory under constant conditions of temperature and humidity. This allowed the effect of temperature to be separated from the generally greater effect of moisture content. Increasingly, however, tests are conducted in the field under ambient conditions. For example, bending tests are conducted in the field using portable equipment to establish allowable properties for visually graded structural lumber. Wood temperatures at time of test ranged from 0°F to 90°F (–18°C to 32°C). Such test data must be corrected to room temperature to obtain meaningful results.

Machine stress rating (MSR) of structural lumber is a two-step process in which the lumber is sorted into grades by nondestructive measurement of modulus of elasticity (MOE) followed by visual assessment of growth characteristics. When grading lumber that may still be warm from kiln drying or cold from outdoor storage in the winter, results must also be corrected for wood temperature. Failure to account for lumber temperature could lead to problems during quality control testing or overly conservative estimates of lumber grade.

What We Did

Green and dry lumber of several species was tested in bending after equilibration to temperatures ranging from 150°F to –15°F (66°C to –26°C). Some of the lumber was tested green, and some at moisture content (MC) levels of 12% and 4%.

What We Have Learned

For lumber at 12% and 4% MC, a linear relationship was used to relate the increase in MOE to decrease in temperature (Fig. 1). For green lumber, a segmented linear regression was developed to describe the change in MOE with change in temperature from 150°F to 0°F (66°C to –18°C). The slope of this relationship was steeper below 32°F (0°C) than above this temperature. Below 0°F (–18°C), the increase in MOE was a function of the decrease in temperature and the actual green moisture content. Empirical and theoretical evidence suggests that "full saturation" with water caused the anomalous behavior below 0°F (–18°C) (Green and others 1999). Linear interpolation was used to estimate values at intermediate moisture content levels. The model is independent of softwood species and lumber grade and is applicable to lumber tested both flatwise and edgewise. For dry lumber, the model is also applicable to MOE values obtained using longitudinal stress wave techniques.

Figure 2— Metriguard's Model 7200 High Capacity Continuous Lumber Tester®.

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Implications of This Research

The MOE–temperature relationships developed in this study are the basis for temperature adjustments used by Metriguard, Inc., Pullman, Washington. Metriguard manufactures equipment for grading MSR lumber and sorting veneer into grades for laminated veneer lumber production.

The addition of a temperature sensor to Metriguard's high capacity continuous lumber tester provides the capability to correct MOE for temperature in real time and at processing speeds (Fig. 2). While processing cold or frozen lumber in cold climates, current practice is to increase the grade thresholds by up to 10%. Correcting for actual temperature eliminates this need. This can result in a significant increase in grade yield by giving proper credit to all pieces that are not at the assumed temperature extreme.

In warmer climates or in warm seasons, no adjustment is typically taken for lower MOE values measured with hot lumber. In this case, temperature corrections can also result in improved grade yield. For example, if grade thresholds are not corrected for temperature, and lumber temperature as measured in the production line varies over a 100°F (38°C) range, then a variability of approximately 11% is introduced. Metriguard estimates that eliminating this variability could improve MSR grade yield by about 12%. The economic impact could be up to $1.2 million for a mill producing 100 million board feet of lumber per year.

What Remains to be Done

We are preparing a second paper giving the MOE changes as a function of temperature for lumber at 4% MC. Analysis of data is continuing on the change in the bending strength of lumber with change in temperature. Some additional testing may be required. The MOE results already obtained (Green and others 1999) are cited in a new American Society for Testing and Materials (ASTM) standard for nondestructive evaluation of wood-based flexural members using transverse vibration. As appropriate, results for both strength and stiffness adjustments will be submitted for possible incorporation into other ASTM standards.

Learn More About It

Green, D.W.; J.W. Evans; J.D. Logan; and W.J. Nelson. 1999. Adjusting modulus of elasticity of lumber for changes in temperature. Forest Products Journal 49(10): 82–94.