RESEARCH in Progress

Coalition for Advanced Wood Structures
a university, industry, government partnership

Advanced Signal Analysis Techniques to Improve Automated Lumber Grading Technologies

The Southeastern region of the United States produces the nation's largest volume of structural lumber, namely the Southern Pine species group, which grows on hundreds of millions of acres across 12 states. Lumber manufacturing is among the top uses for this timber. Annually, 10 to 15 billion board feet are produced. To keep up with growing domestic demand and maintain a favorable trade balance for U.S. producers, the maximum dollar value must be obtained from every piece of lumber. Additionally, given the global nature of the lumber commodity, domestic unit processing times and costs must continually be reduced.

Background

The strength of wood and lumber products is important in the design of engineered structures. Structurally rated pieces, be they poles, lumber, plywood, glulam beams, or other, command premium market value. For private sector businesses to stay economically viable, they must capitalize on these higher value products. It has been determined that acoustic wave analysis can be used to assess the global stiffness of individual members or lumber specimens. This finding helps automate and increase uniformity and accuracy in lumber grading. To date, however, it has not been possible to acoustically locate strength-reducing-characteristics within lumber specimens. Thus, there is a technical barrier to higher value lumber processing, particularly with respect to developing trimming solutions, which cut pieces of lumber to their final lengths, based on maximum value, before packaging.

Automated lumber grading equipment in use.

Objective

The objective of this study is to develop advanced analysis techniques to enhance the performance and accuracy of automated structural lumber grading. This work seeks to use advanced signal analysis to locate major strength- and stiffness-reducing characteristics along the length of lumber specimens. In this manner, the trimming operation during lumber production can be more fully automated, thereby increasing efficiency and accuracy.

Approach

Initially, automated lumber grading technologies that utilize acoustic wave transmission will be reviewed.

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16- and 20-ft-long pine lumber with minimal strength-reducing characteristics that will be used to develop the initial clean wave signatures.

Fundamental wave properties and their relationships to physical and mechanical properties will be examined along with advanced signal analysis techniques, with specific reference to the use of Fourier series analysis techniques. Then fundamental wave behavior in full-size Southern Pine lumber specimens will be examined. The study will begin with the examination of wave behavior in full-size lumber specimens that do not contain significant strength-reducing defects. Acoustic wave signatures will be recorded and analyzed.

Next, simulated defects of various sizes and shapes will be introduced in the specimens, and corresponding wave forms collected and analyzed. Key parameters will then be identified. It is anticipated that the acoustic wave signatures can then be used to identify both the size and location along the length of the larger stiffness-reducing characteristics. This information is required for optimized trimming and merchandizing for maximum lumber value. For example, strength- or stiffness-reducing characteristics near the end of a specimen are detrimental for tension members in trusses, but less troublesome for bending members.

Finally, a random sample of 100 Southern Pine structural lumber specimens will be evaluated nondestructively using the key parameters identified in the earlier work. These specimens will then be tested to failure, in bending, according to ASTM D198. Correlative relationships will be developed between nondestructive test parameters and static elastic and strength values.

Expected Outcomes

This cooperative effort will provide lumber producers and equipment suppliers with additional tools and technologies to optimize and automate the lumber manufacturing process. In this manner, domestic timber producers and lumber manufacturers can enhance their global competitiveness. By reducing production time and costs and improving accuracy, U.S. producers will be better able to grow their respective businesses and create new technologically advanced jobs.

Timeline

The project was initiated in June 2017. In the first year, fundamental wave properties will be examined, preliminary testing will begin, and equipment will be developed. In the second year, testing and advanced signal analysis of full scale clear specimens will be completed. The third year will include sampling of mill run lumber, subjecting lumber to advanced signal processing, and nondestructive and destructive testing, followed by development of correlations between wave signatures and strength-reducing characteristic locations.

Cooperators

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