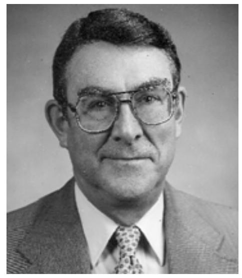
Machine Grading Procedures under the American Lumber Standard

William GALLIGAN, P.E.
Consultant
Salem, Oregon, USA
w.galligan@att.net



William Galligan holds an MS in Chemical Engineering from Washington State University where he is an Adjunct Professor. He is a Courtesy Professor at Oregon State University. He has been involved with mechanical grading of wood for 45 years.

Donald DEVISSER, P.E.
Technical Director
West Coast Lumber Inspection Bureau, Portland, OR, USA
devisser@wclib.org

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Donald DeVisser has a BS in Engineering from Michigan State University and an MBA from Portland State University. He is responsible for qualification and quality control system development for machine grading of lumber for Bureau members.

Summary

Increased interest in the export of machine graded lumber from Europe to the United States has required European lumber producers to address the requirements of the American Softwood Lumber Standard (ALS). Grade selection, grade qualification, quality control and process control settings are all mill-specific and test-based. Each producer is required to have a third-party, ALS-approved agency to qualify each grade, width and species of lumber by test. The subsequent daily quality control program is based on these tests and is crafted with the ALS-approved agency to provide efficient feed-back on performance of the grading system. In addition, this program provides insights for optimization of the grading process. By observing the quality control results and conducting appropriate additional tests, a producer can adjust the mill's test-based system by shifting machine grade acceptance settings to increase yield while continuing to assure conformance to the performance criteria established with the supervisory agency. Test data can provide justification for increased design values of selected properties. Consequently, the lumber producer's grade selections and mill yield can be linked to both the market demand and the timber resource.

Structural lumber, machine grading, American Lumber Standard, qualification, quality control.

1. Introduction

Machine stress-rated lumber grading has been in existence in a number of countries for over 40 years. In the United States, machine grading products are alternatives to visual grades in end-uses that vary from metal plate wood trusses to structural glued laminated beams. The size of this market provides an attractive alternative consumer for foreign lumber producers. However, products for that market must meet the United States machine grading standards. Since these standards were developed primarily to serve the industry in the United States, the procedures evolved under the American Softwood Lumber Standard (ALS) [1] and its member grading agencies. Under this standard, the procedures quickly evolved to a test or "out-put"-based system for both qualification and quality control [2], thus differing from machine grading systems in some other countries that used machine control based on a global resource values. Recently, both machine control and “output” control have been accepted in European practice [3].

The ALS mill-specific, test-based grading system offers both challenges and opportunities for the producer. The challenges include the requirement to conduct mill-based qualification tests on each grade, size and species of lumber and, subsequently, to conduct daily quality control to assure adherence to the grade specifications. The opportunities include the ability to optimize the mill machine grading system for specific markets, for specific timber resource, and for mill-processing options - none limited by broad geographic species-based criteria. The characteristics of the United States system of machine grading may require study by prospective producers because of the significant differences with their current system. This paper is a brief introduction to machine grading under ALS; references for additional reading are suggested.

2. ALS Mill-Specific Qualification and Quality Control

Under the ALS [1], grading agencies are responsible for qualification of mills to produce machine graded lumber. For example, the West Coast Lumber Inspection Bureau (WCLIB) Standard for Machine Stress Rated Lumber [4] contains the definitions of machine grades, qualification and quality control requirements, and illustrations of quality control procedures. The objective of this Standard is to assure conformance of lumber machine graded under WCLIB supervision to the allowable design values assigned to the grades. The ALS provides the basis for the WCLIB Standard; the American Lumber Standards Committee (ALSC) provides interpretation and specific guidance.

ALS machine grades contain both visual and mechanical grading criteria. Consequently, both the grading machine and the visual graders in an approved system must be qualified.[1].

2.1 Qualification

Agencies supervising grading under ALS have qualification standards under which lumber manufacturers may become qualified to grade stamp machine graded lumber. For example, stress rated (MSR) and E-rated laminating lumber are described in WCLIB Standard Grading Rules No 17 [5]; the accompanying Machine Grading Standard [4] incorporates the methods by which the agency enforces the ALSC qualification requirements. It also specifies supplemental standards. An example of supplemental WCLIB requirements is the qualification test in tension parallel to grain. This requirement is in addition to traditional edge-wise bending, based on several years of research on tension/bending ratios [6]. Also required are specific gravity measurements that broaden the technical data base and provide the basis for optional methods of developing allowable design properties in compression perpendicular and shear. The generic test requirements and relationships used to develop allowable design properties are referenced in ASTM International (ASTM) Standard D 6570-00a [7]. ALS grading agencies incorporate the relevant portions of D 6570 in the assignment of allowable properties to the machine grades.

The company may select the grades for qualification, depending upon market targets and their resource capability. Each machine grading facility must qualify the machine grades produced at that facility; each grade of each size of lumber chosen for machine grading must be qualified by test. For example, WCLIB requires a sample of at least 53 pieces meeting the anticipated grade requirement[4]; although, experience shows that it is often an advantage to use a larger sample. The larger sample provides more information both for qualification and for establishing the basis of subsequent quality control. Also, a producing facility may conduct a series of tests to focus on the resource capability, especially if their specific lumber resource has not been previously evaluated.

A US Forest Products Laboratory publication, GTR-7, provides background and procedures for evaluating the producer resource [8]. With foresight, it is possible to incorporate some of the concepts of sampling and evaluation of GTR-7 into the formal qualification requirements of the supervisory agency. Based on qualification results, the producing facility makes market-based decisions about actual grade**s** to grade stamp.

The graders who will be applying the visual criteria to the machine grades must be qualified by test to the grades for which they are responsible. This qualification is conducted by the supervisory agency as stipulated by ALS procedures.

2.2 Quality Control

Quality control requirements for machine stress rated lumber are also a responsibility of the supervisory agency. For example, the WCLIB Standard requirements include maintenance of a machine grading quality manual and regular inspections of the production, the accuracy of the plant quality control equipment, and the quality control records [4]. The plant is required to conduct daily sampling and testing of machine grades. Additional testing may be required by changes in calibration of the grading machine, changes in the grades produced, results of quality control testing, and production stoppages or changes in composition of production.

Quality control under ALS is mill and grade specific, focused on conformance to the grade specifications. The producer, together with the agency, develops a quality procedure that meets ALSC guidelines; all grades and sizes must be represented in sampling and testing. Provision must be made for out-of-conformance conditions, disposal of off-grade material, and re-qualification. The agency standards may also provide specific quality control suggestions, with model data sheets and explanatory examples. The quality monitoring procedure, CuSum, is commonly used as one acceptable method of measuring conformance of mill grades. A detailed explanation of CuSum, as interpreted by WCLIB, is found in reference [9]; a recent review relating to European use is in reference [3].

Process control aspects of quality monitoring are not usually addressed in the agency standards since they relate more directly to mill yields and mill operating procedures. These aspects of mill operation may be assisted by the agency upon request but are not part of the ALS system.

3. Producer Advantages - Optimizing the Grading Process

Qualification and quality control at individual grading operations results in yield and performance data focused on each mill operation. Thus, the management of each mill can determine how the mill's timber resource and processing preferences interact with the machine grading and market choices. As long as the grades continue to adhere to the test-based performance criteria, management has choices that may result in market or yield advantages. These choices include 1), selecting grades and adjusting acceptance criteria to match the timber resource; 2), changing grade selection to meet changes in the market; 3) adjusting the grade mix, especially the coordination of visual grades and machine grades, to obtain optimum grade yields; 4), and enhancing the quality monitoring system with additional data, resulting in additional allowable property claims for machine grades. Each of these choices is mill specific and, because each is performance test-based, must be coordinated with the supervisory agency.

3.1 Optimizing for the timber resource

While the general principles of machine grading are widely applicable to softwoods, the specific grading choices of a mill depend on the specific resource of that mill. One example in United States practice is the machine grading of mixed species groups. These species are mixed for grading and marketing on the general basis of similar properties; yet, they are not identical and, in a particular region, one species may dominate, influencing the yield of specific machine grades. Thus, mills in different parts of the producing region may make different grading choices. Another example of the influence of resource is the variation of quality and even property relationships within a species over the growing region. This is evident over the large Douglas Fir region of North America and has been documented for Norway Spruce within Sweden by Chrestin [10]. To counter this effect and turn it to advantage, a mill may adjust grade selections and machine acceptance criteria to optimize use of the resource. A mill-based qualification and QC system permits this flexibility. This is commonly called an “output” controlled grading system; it’s potential for Swedish Norway Spruce was noted by Chrestin.

3.2 Reflecting the Market with Grade Selection

Machine graded lumber industry has evolved from a supplier of specialty “high-end” grades to a supplier of grades that cover a wide range of grade levels for customers that vary from metal-plate wood trusses to laminating lumber and wall and roof components [11], [12], [13]. Today, a machine grade lumber producer can target a specific market, or a portion of a market, and adjust the machine grading operation for that target. While many of the grades may be classed as commodities, a producer may focus on a niche and, with the agency assistance, qualify a grade for that use.

3.3 Optimizing within the Mill Operation

Optimizing production for machine grading is not limited to the log resource or to the machine grading operation. Within the mill, trimming choices, drying quality and the coincident non-machine grades all affect the efficiency of the machine grading operation. This latter effect, coincident non-machine grades, is critical because it is unlikely that machine grades will be the only product. It is important to sample the candidate machine grades from the lumber containing the non-machine grades, not only because this provides the best test basis for qualification but also because the impact of grade selection on all grade yields and performance is important to the mill. GTR-7 [8] discusses sampling at time of qualification; a broader view of the interactions with non-machine grades and with mill operating variables is found in reference [11]. Again, a test-based system reflects the presence of all grades pulled from the resource; changes in these choices may require re-qualification of affected grades.

3.4 Allowable Property Optimization

Machine grading provides the opportunity of quantifying many allowable properties in a more specific manner than is possible in visual grading because of the selection criteria used in the grade sorting process - usually stiffness or density. In addition to the more common properties, one “additional” property is the modulus of elasticity in a flat-wise orientation. Since many machines measure stiffness in this orientation, this property is easily assigned where desired, for example, in some wood trusses and in laminating lumber. [11] Other properties such as compression perpendicular to grain (Cperp) and shear vary little or not at all in their assignment across visual grades; in machine grading, the option exists to use the grading process to estimate density (specific gravity in the United States literature) from which allowable properties for both Cperp and shear can be derived specific to the grade. [5], [11]. This is of particular interest for critical uses because the higher grades will have higher densities and, consequently, higher Cperp and shear properties. For species that have an average density lower than market competition, the grading process can enhance metal fastener design for the upper grades by identifying a higher density value for those grades. Special marketing emphasis may be required to realize these optimization benefits since they are not characteristics of the commodity competition.

3.5 Monitoring and Optimizing Yield

A test or "output"-based grading system is dynamic. Qualification provides data on lumber performance not normally seen in a mill providing only visual grades. The quality control program produces daily information on adherence to the specification. The regularity of these samples permits the quality system to be easily enhanced by additional measurements to provide process control information on many of the intermediate stages of the process. This includes sawing and planing practices, kiln drying, resource quality, and visual grading [11].

It is useful for the producer to look at the production of machine grades as a model-based matrix, since the sorting process of machine grading is one of interaction where the differing selection criteria, both mechanical and visual, of each grade influence the yield and test performance of adjacent grades. An explanation of this relatively simple matrix, the resulting interactions between grades, and the introduction of *specification* and *acceptance* terminology are detailed in reference [2]. A realistic example is illustrated in GTR-7 Appendix C - Matrix Evaluation [8].

4. Conclusions

Producing machine graded lumber under the American Softwood Lumber Standard (ALS) poses challenges for producers in countries who have been operating under different machine grading systems. These challenges include the need to conduct qualification tests on grades, sizes and species on a mill-specific basis regardless of geographic location. Subsequent quality control is based on mechanical tests conducted daily to assure conformance to the grade specifications. While these requirements may suggest a new or different burden on the producer, the ALS system offers significant flexibility to the producer. Under this system, the producer may 1), adjust the grading machine to match the timber resource; 2), select and modify grades to meet both the market needs and the capability of the mill; and 3), enhance specific machine grades with higher shear, compression perpendicular-to-grain, and density values based on qualification and more comprehensive quality control.

5. References

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