GUIDELINES FOR ASSIGNING ALLOWABLE PROPERTIES TO VISUALLY GRADED FOREIGN SPECIES BASED ON TEST DATA FROM FULL SIZED SPECIMENS

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Introduction

Currently there are several alternatives for assigning allowable properties to domestic species. For visually graded lumber two methods are approved by the Department of Commerce under the American Lumber Standards (ALS) system. They are:

a. Using test results based small, clear specimens (ASTM D 143) and apply criteria given in ASTM D 245 and D 2555, or
b. Using test results based on full-size, commercially graded lumber (ASTM D 4761 or D 198) and apply the criteria given in ASTM D 1990.

Domestic species may also be graded by mechanical, or other automated, procedures approved by the ALSC (Green and Shelley, 1993). All of these procedures are only applicable to lumber produced from species grown in the United States or Canada. They are not applicable to lumber produced from foreign species but graded in the United States. They are also not applicable to lumber produced from species that are native to the United States but that are imported into the United States from a foreign country and graded by U. S. procedures.

For dimension lumber made from species not grown in the United States or Canada the Department of Commerce has approved grading by visual procedures with property assignment by "testing-inference-quality control (TIQC)" procedures (Galligan and Ethington, 1975). The philosophy of the TIQC procedure was to establish if a grade of lumber produced from an imported species meet or exceeded an ALSC approved grade for a domestic species. This was done through tests of structural size lumber and analysis of results according to procedures of ASTM D 2915. It required judgmental decisions and inference for grades and sizes not tested and required a continuing quality control program. Although the procedure has been attempted several times, it has only been successfully used once. No ALS-grade marked lumber has been produced using the TIQC based approval. Now the TIQC procedure is cumbersome and archaic. In 1973, when the original TIQC document was written, there was no approved ASTM procedures for deriving the allowable properties of visually graded lumber from tests of full size pieces. There were, however, testing procedures and analysis guidelines. Thus the TIQC document provided needed guidelines for the interpretation of test results based on full size specimens. In 1991, however, ASTM standard D 1990 became available and was approved by the Department of Commerce for assigning properties under supervision of the American Lumber Standards Committee. This standard provides most of the guidelines that were missing when the original TIQC procedure was written.

The current grading and property assignment system in the United States contains no provisions for quality control through direct assessment of properties. Unlike native species, however, we have no history of usage of foreign species, and may have little ability to judge potential changes in lumber quality due to changes in resource. These reasons lead to the inclusion of quality control provisions in the original TIQC procedure. Quality control is still an essential component of property assignment. Thus QC guidelines are an essential part of a foreign species acceptance criterion.

Objectives

The objective of this document is to provide philosophy and guidelines for the assignment of allowable properties to visually graded dimension lumber produced from trees not grown in the United States. This document assumes, as a starting point, the procedures of ASTM D 1990.

Scope

When discussing options for assigning allowable properties to lumber produced from imported species there are many options that could be considered. The procedures described in this document assume that:

1. The procedures are applicable to lumber produced from both imported softwood and hardwood species.
2. The lumber has been graded under supervision of U.S. or Canadian grading agencies.
3. The procedures are referenced to grading and property assignment procedures approved under the ALSC system.
4. The procedures are applicable to dry lumber having maximum moisture content of 19% at time of grading.
5. The procedures are applicable for development of allowable stresses for bending, modulus of elasticity, tension parallel-to-the-grain, compression parallel-to-the-grain, compression perpendicular to the grain, and shear parallel-to-the grain, as well as to assessment of specific gravity.
6. Mechanical property test data, if required is assumed to be obtained on full size lumber tested according to procedures given in ASTM D 4761, D 198, or clear wood procedures given in D 143. Specific gravity is determined according to method A of ASTM D 2395.

This document does not exclude the development of procedures for other properties, grading methods, or grading systems. But these alternatives are not within the scope of this document.

Approach

The approach to assignment of allowable properties will he based on ALSC approved procedures for assigning allowable properties to domestic species graded into dimension (2- to 4-inch thickness) lumber grades by ASTM D 1990. The approach is consistent with the proposed procedure for mechanical grading of species not grown in the United States (Green and Shelley, 1993).

It is necessary to first demonstrate that the ALSC procedures are applicable to the species, or species group, for which property assignment is sought. This procedure is called "qualification of the species". For visually graded lumber the qualification sample establishes the allowable properties and provides data for judging the applicability of D 1990 size and grade trends. To qualify a species it is necessary to first determine which

of the four population categories, listed below, that the species falls. Then a sample should be obtained which contains the full range of quality over which future shipments might be anticipated. Finally, tests must be conducted to show that ALSC procedures are applicable to this species. Additional information obtained from foreign or domestic laboratories may be provided as a supplement to the information obtained in the qualification process. However, such data may not be used in lieu of the qualification process. Following qualification of the species, shipments may be graded according to standard ALSC approved agency practice if the quality of the material is within the range defined by the qualification sample.

Qualification of the Species

Defining the Population.

Species for which grading approval is sought shall be classified into one of four categories: 1) softwood species from temperate regions, 2) hardwood species from temperate regions, 3) softwood species from tropical regions, and 4) hardwood species from tropical regions. If there is no clear answer to the category selection, the most restrictive assignment of the alternatives under consideration shall be used.

Temperate softwoods. Current ALSC approved for visually graded dimension lumber are primarily based on data and commercial grading experience on domestic softwood species. Considerable data exists on property relationships for these domestic species (Canadian Wood Council, 1988; Green and Evans, 1987; Green and Kretschmann, 1991). Considerable data also exists to relate foreign softwood species from temperate zones to the data for domestic species (see, for example, Barrett and Griffin, 1989; Green and Kretschmann, 1989). In addition, clear wood data may be available for these species which may be used to verify compatibility with property relationships for U.S. species. Species qualification procedures are minimal for temperate softwood species. With experience, it may only be necessary to test these species in bending or tension parallel to the grain.

Temperate hardwoods. Hardwood species from temperate regions would be expected to have defect patterns and property relationships similar to those of domestic hardwood species. Research has verifying the applicability of ALSC procedures lumber to domestic hardwood species which do not have interlocked (Green and McDonald, 1993-a, -b), Information on species with interlocked grain is given below and in Davis, 1962. Again it is anticipated that qualification procedures would be minimal for temperate hardwood species which do not have interlocked grain.

Tropical softwoods. Softwood species from tropical regions may contain few knots. Little information is currently available on the properties of lumber tested in full size dimensions for such species. However it is reasonable to assume that relationships that apply to temperate softwoods also apply to tropical softwoods.

Tropical hardwoods. Hardwood species imported from tropical regions are the most variable and least understood of the four classifications discussed above. The majority of

data on full size lumber is for lumber tested in bending. This data indicates that MOE-MOR relations are sufficiently correlated to allow mechanical sorting of most species (Green and Rosales, 2006). Interlocked grain frequently occurs in tropical hardwoods (Chudnoff, 1984). Limited research suggests that for tropical hardwoods without interlocked grain property relationships are the same as those of temperate hardwoods and softwoods. For species that typically have interlocked grain, property relationships currently assumed for domestic species may not apply (Green and Rosales, 2006). Available literature also indicates that certain tropical hardwood species may have growth characteristics, such as brittle heart, which are not always apparent from visual inspection (Chudnoff, 1986). Species which tend to have such problems may not be reliably sorted by mechanical procedures based on strength- stiffness relationships (Collins and Amin, 1990). Because of the lack of information on the properties of tropical hardwoods, it is necessary to qualify the applicability of any assumed property relationships to the species being sampled.

Species or species group. It is important that the species, or group of species, being tested is identified. The submission must include the scientific name(s) of the species being tested. If the species is not known, then herbarium specimens should be taken during logging and these used to establish the species being imported.

Geographic distribution. A description shall be provided of the geographic range over which future shipments are anticipated. The sample selected for the qualification process should be representative of material from this range. Thus it is expected that the range in quality of the qualifying sample will be broader than would he required just for a narrow range of anticipated grades that may be produced. Note shall be made of any special considerations in selecting the qualification sample. Such special considerations might include exclusion of lumber from the extremes of the geographic range of the species, the existence of extensive stands of fast grown plantation material within the geographic area, restriction of the qualification sample to peeler core stock, etc.

Lumber properties are known to vary considerably with the growth conditions under which the trees are grown. For example, traditionally restrictions have been placed on assignment of allowable bending properties for very fast grown, or very slow grown, domestic softwoods that are visually graded. Less is known, however, about the effect of growth conditions on absolute levels of properties, or relationships between lumber strength properties. Some evidence suggests that the procedure used to assign allowable compression strength parallel-to-the-grain to visually graded dimension lumber may be conservative for fast grown plantation stock, but the procedure used to estimate tensile strength may not he (Green and Kretschmann, 1991). Thus judgments will need to be made on the applicability of the data from the qualifying sample to future shipments.

Sample selection.

A critical assumption of D 1990 is that the specimens that were tested are "representative" of the species for which design values are to be assigned. With foreign species it may require considerable judgment on the part of the submitter to select a representative. Only general guidelines can be given here. All available information on factors affecting lumber properties should be used in selecting the specimens. If data on

property or density distributions are not available, the care should be taken to assure that a range in possible lumber quality. In general, it is advisable to assure that the lumber is cut from more logs, rather than fewer. It is also advisable that the logs be obtained from as many geographic locations as possible. In no case shall the lumber come from only one geographic location. For some species, multiple elevations in one geographic area may be substituted for multiple geographic areas.

Because there is so little information on "density (grain)" classifications, it is suggested that special density categories not be used with foreign species. If special density categories are to be used, they should be treated like a new species, with a testing program that conforms to all the other rules.

Production processes. Production processes may also affect the properties observed in the verification sample, and thus the approval granted for future shipments. This should include whether or not the lumber is from peeler core stock, whether maximum kiln temperatures were used in the drying process, etc. These factors shall be discussed in the qualifying submission. Future shipments shall be monitored by the grading agency for compliance with the specifications of the qualifying submission.

Selection of D 1990 Alternatives.

ASTM D 1990 offers several alternatives for testing and property assignment. Application of these alternative procedures to U.S. and Canadian lumber has evolved over time, and this evolution has been guided by the judgment of a wide range of professional and consensus organizations. Application of these alternatives to foreign species requires additional judgment which, of necessity, may be more conservative than allowed for native species.

Minimum sampling matrix. D 1990 allows allowable stresses to be derived for either a single grade, or a single size, or a full matrix of grades and sizes. The qualification sample, by definition, is intended to contain a range of lumber quality. Therefore a single grade of lumber cannot be used in the qualification sample; even if only one grade of lumber is to be sold initially. However, it is possible to qualify only one size of lumber. For example, material having the full range of quality in Construction, Standard, and Utility grades may be qualified by testing only 2x4's. If only one size of lumber is qualified, other sizes may not be grade stamped without submitting an additional qualifying sample.

Alternatively, a full matrix of grades and sizes may be included in the qualification sample. This shall include a minimum of 3 sizes, within the range of 2x4 to 2x12, and two grades. To use the grade modeling procedure of D 1990 the grades Select Structural and No. 2 must be used. However, it may be desirable to include a lower grade also.

Number of Specimens in the Matrix. The minimum sample size depends on the basis for calculating allowable properties. If allowable properties are desired for an individual species, then approximately 360 specimens are required per grade, size, and test mode. If, however, the "species grouping" procedures are to be used, then the minimum sample size is approximately 60 pieces per size, grade, and test mode. If allowable properties are

to be obtained by grouping the new data with data for domestic species (or with other foreign species), then the total number specimens per size, grade, and test mode must he at least 360 for the group.

Selection of Test Modes. D 1990 allows testing in all test modes, or allows testing in selected test modes with estimation of other properties using conservative equations. Bending MOE, shear parallel to the grain, compression perpendicular to the grain, and specific gravity data must be obtained for all population categories. Shear, C-perp, and specific gravity specimens may be taken from undamaged ends of bending specimens. For temperate softwood species and temperate hardwood species additional testing may be limited to either determination of MOR or UTS, with UCS and either MOR or UTS determined using conservative equations of D 1990. Tropical softwood species may use the conservative procedures of D 1990 if evidence is presented to indicate that these procedures are conservative for the species being evaluated. This evidence might include such information as anatomical similarities to domestic species, similarity in clear wood properties, lumber test data from domestic or foreign laboratories, etc. Alternatively, some data on Fb-Ft and /or Fb-Fc relationships may be obtained in the verification process. Until more information is available, tropical hardwood species must be tested for MOR and UTS. The conservative equation of D 1990 may be used for estimating UCS if evidence is presented to show that this procedure is conservative (Green and Rosales, 2006).

Test procedures.

Testing for lumber properties shall follow the procedures of ASTM D 4761 or D 198. To avoid interpretations problems, it is strongly suggested that all tensile tests be conducted with a constant clear span between grips. For similar reasons, it is also strongly suggested that the lumber be equilibrated to a constant moisture content and temperature (see notes in next paragraph). If it is not possible to equilibrate the specimens, evidence must be presented to justify moisture adjustment procedures. It should be noted that properties for visually graded lumber are commonly expressed at 15% moisture content for mechanical properties, and on the basis of oven dry weight and volume for specific gravity.

The lumber for the qualification sample is required to he equilibrated to a moisture content of 15% because, in general, we do not necessarily know appropriate procedures for making property-MC adjustments for foreign species. A MC of 15% was selected because: it is the highest MC for which it is recommended to grade foreign species, it is known that the UCS/MOR relationship is conservative relative to that at 12%, and because we wish to avoid MC's less than 10% in our sample (D 1990 makes no recommendations for adjustment of properties at moisture content levels below 10%).

With lumber from temperate softwood species, the moisture adjustment procedures of ASTM D 1990 may he assumed to apply. Thus, while it is highly recommended that such lumber he equilibrated to 15% moisture content prior to testing, the lumber may be allowed to reach a uniform MC other than 15% and the properties then adjusted by D 1990 procedures.

Compression perpendicular-to-the-grain and shear tests may be conducted according to procedures given in ASTM D 143. However, it may not be possible to cut these specimens according to D 143 specifications. In the absence of alternative data, we note that studies by Bendtsen and Porter (1979) indicate that a 1.5 by 2.0 inch shear specimen give results equivalent to that obtained using the standard 2.0 by 2.0 inch specimen. Also note that a study by Kunesh, 1968, indicates that a 1.5 inch by 6 inch long specimen, 2 inches thick, should give results comparable to the standard 2 by 6 inch long, by 2 inch thick specimen. For both shear strength and C-perp stress should be calculated using the actual stress area of the specimen. Note that determination of the shear strength for species with interlocked grain requires estimation of the area of the failure surface, not simply assuming a surface area from the specimen dimensions, to avoid over estimation of shear strength (Green and Rosales, 2006). Specific gravity shall be determined by method A of ASTM D 2395 and moisture content determined by method A of ASTM D 4442. Moisture content may be taken using an electrical resistance moisture meter if information is available on how to calibrate the meter for the species being tested (some information on moisture meter correction factors for foreign species is given in Simpson, 1994).

Reporting of Results.

A written report shall accompany each submission. The report shall give information about the species known to the submitter. This shall include a summary of all mechanical and physical properties determined from the qualification sample, as well as a copy of the data suitable for electronic analysis by computer. This report shall also include information on the range over which the species grows and a discussion of the locations(s) from which the qualification sample was obtained. Additional information relating to machinability, treatability, durability, etc. should be included if known.

Quality Control

The quality control program recognizes the need to assure that the individual units of lumber produced from the foreign source have the same quality as the lumber that was tested in the qualification sample. For lumber from a foreign source it may, or may not, be possible to assure that future production was fairly represented by the qualification sample. Therefore, only general guidelines are possible. At the time of submission the submitting agency should specify the basis for picking the combination to be monitored. In general, visual grading alone is not considered sufficient to assure consistency in lumber quality from an unknown source. Thus some additional form of quality control procedure is desirable. Unlike MSR limber, production of visually graded lumber from foreign species is likely to involve multiple grades. It is not necessary to monitor all grades and sizes being produced at a given mill at one time. The guiding principal is that at least one grade-size combination must be monitored at all times that lumber is being graded, The exact form of the quality control should be justified by the requesting grading agency at the time of submission of the data for the qualifying sample.

For species from temperate regions, and for softwoods from tropical regions, quality control procedures may emphasize nondestructive tests such as MOE and specific gravity. Agency experience with quality control programs for MSR lumber could serve

as a starting point for formulation of an appropriate quality control program for visually graded lumber produced from foreign species. For tropical hardwoods, the quality control program must involve destructive testing of a portion of production, and the test must be for MOE and either MOR or UTS.

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