The Metriguard Messenger

Celebrating 35 years of service to the forest products industry

30 September 2008 MM-080930 Pullman WA - USA

Grade Yield and Profit in Structural Dimension Lumber

James D. Logan, PE
President, Metriguard Inc

Overview

Getting the most profit from your structural lumber involves more than simply buying the appropriate equipment and cranking out the lumber product. We sort lumber into grades to make it acceptable for construction under the various building codes, and that process increases its value. Without grading the lumber, properties are simply too variable to be useful in structural design.

Machine stress rating, or MSR, is a process of grading by machine into stress grades that have well defined properties, and we can predict reliably the strength properties of the higher strength pieces so we can place these pieces in a grade so that the highest and best use can be made of the lumber. All this makes the lumber more valuable.

Again, buying the equipment and running the lumber through it is not quite enough. We show here how to match up the lumber grade combinations with the resource and the market so we can optimize the value added by the grading process. In one example shown here the value added by selection of the grade combination varies between $15/mbf and $74/mbf. Without going through this process the mill operator has no way to tell where in this range lays the grade combination currently being produced.

Metriguard is offering a 3-step process to accomplish this:

1. First we make sure the equipment is working correctly, that all the equipment upgrades are installed and that the equipment is making its measurements accurately and is calibrated to a standard.

2. Second, we take a large sample of lumber, gather machine readings and visual quality level (VQL) for each piece, together with lumber prices FOB mill for all the MSR and visual grades that are contemplated to be produced at the mill.

3. Next we use a Yield Analyzer computer program to determine the potential grade yield for every grade in every grade combination that can be produced practically at the mill. This usually means the single, two and three-grade MSR combinations plus the visual downfall grades that can be produced with each MSR grade combination. This information is then used to select the most profitable grade combinations, and get the new grade combinations certified for production.

Step 1 deals with maintenance issues, and should be repeated on an annual basis. When the 3-step process is finished the mill is supplied with a spreadsheet into which new prices can be entered and optimal grade combinations checked. As long as the resource stays relatively constant step 2 does not need to be repeated. Step 3 can be repeated any time there is a significant change in price structure in the market. The output from the spreadsheet will tell the mill operator when they need to consider changing grade combinations.

Introduction

Products are manufactured for the purpose of making money. When we keep this basic principle in mind we can focus on the strategies we use to convert a raw material into one more valuable and desirable in the marketplace. This value-added process starts in selecting nursery stock for the forest and ends with the final product all gussied up in its marketing wrap. A reward system based on profits would place volume production secondary to quality in the product, but recognize that both volume and quality are necessary to the final profit motivation.

A while back I was told that grade yield wasn't all that important to the lumber producer. I can think of only a couple of circumstances where this would be true. One would be if all the lumber grades sold for the same price, certainly not a condition in place today. I've been watching the lumber market for about 35 years now and have never seen that kind of flatness. The other case would be if revenue had no bearing on profit or if profit were not important to the owners. I haven't seen that either.

Based on my personal observations, grade yield really is important to the structural dimension lumber producer at least 99.4% of the time. So it would make sense to operate in a way that maximizes or at least locally optimizes the grade yield.

For the structural dimension lumber producer, one good place to start is with machine stress rating (MSR). [1, 2, 5] Once that decision is made you have the additional choices of equipment, grades and market.

The key indicator property for MSR grades is the modulus of elasticity, or E. For a given piece of lumber the E value will vary along the length due to non-uniformity in grain structure, microfibril angle, moisture content, knot pattern and wood density. E, the measure of wood stiffness, varies by species, growing conditions and by where the specimen came from in the log. [3, 4]

Getting an accurate E reading is the starting point for good repeatable and reliable machine lumber grading. We use statistical expressions for evaluating repeatability and correlation with off-line quality control measurements. The coefficient of determination, r^2 is a measure of the variability in a second set of measurements that is determined or predicted by a first set of measurements. If the measurement results are identical between the first and second sets, then the predictability is perfect and the r^2 value is 1. If you see a perfect scatter when you plot the second measurements against the first, then the r^2 value is 0. If r^2=0.9 between the QC measurement and the production line measurement, then 90% of the variability in the QC measurement is predicted by the production line measurement.

For typical structural dimension lumber, the edge-wise E measurement typically has r^2=0.9 with the long-span flat-wise average E measurement. If you compare long-span flat-wise E with Average E from Metriguard Model 7200 HCLT production measurement you see r^2 at about 0.98 to 0.99 unless something is wrong. It doesn't get better than that, and correlations are only that high if the production line equipment is measuring the same property in the same way as is the quality control measurement.

Quality Control and Process Control

Most MSR quality control processes involve a measurement of edgewise bending E and strength and this kind of test has served the industry well over the past thirty years or so.

As long as we are measuring edge-wise properties in the quality control process and flat-wise properties in the production process there will be a variability of about 10% which will have to be accounted for in the form of higher threshold settings to keep the process in control.

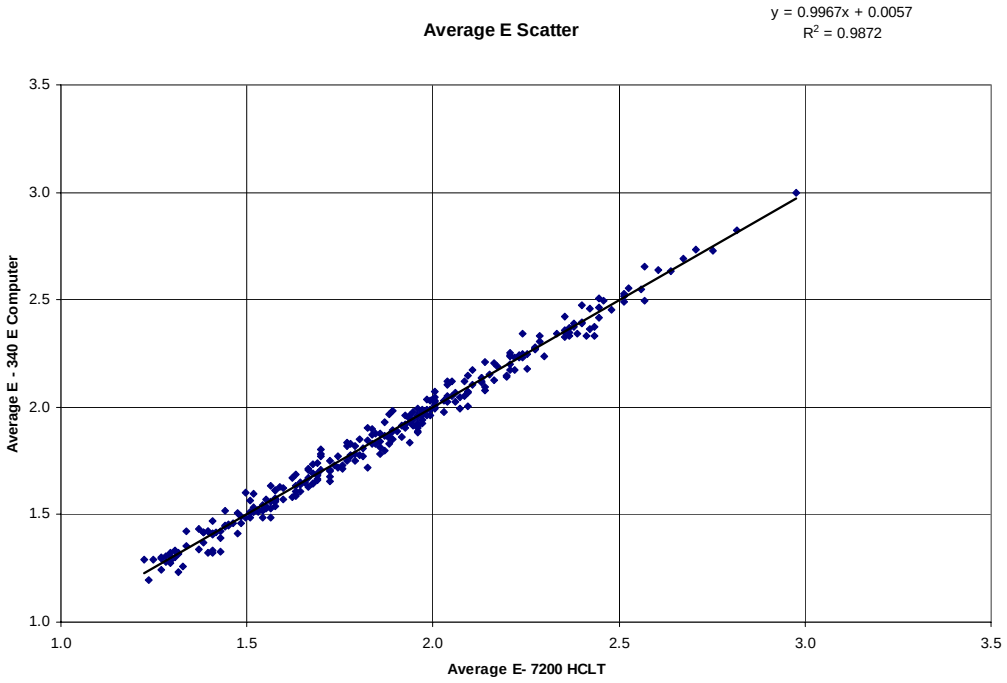

Figure 1. This graph illustrates the correlation we expect to see between Metriguard Model 7200 Average E and long span flatwise E measured in this case by means of a transverse vibration E-Computer. In this case the coefficient of determination, r^2 is 0.987, indicating that all but 1.13% of the variability in the secondary measurement is explained by the primary measurement.

This also means that if you are using the quality control information to reveal any change in the process, your information has a 10% "noise" that prevents accurate determination of small changes in the process. This can be avoided by using separate off-line tests for process control and calibration.

When Metriguard service technicians calibrate an MSR system using a wood sample, we require r^2 of at least 0.95 between the machine readings and the off-line test readings before proceeding. This calibration process always involves a long-span flat-wise measurement of E. This can be obtained by a series of flat-wise measurements taken in a bending proof tester, or by means of a Metriguard Model 340 E-Computer. This way one can get a measurement that is not confused by the additional variability that arises from using similar but different measurements for this purpose, such as an edgewise E compared with a flatwise E.

In the same way as good clear vision is important while reading or driving, a tight correlation in the calibration process makes it possible to see small variations when they occur. When we can stabilize the calibration of the MSR production equipment we can reduce the grade threshold settings and improve the grade yield. So, unless you are using the Metriguard Symmetric Bar calibration system, it would pay to use a separate long-span flat-wise measurement for calibration of the equipment. This recommendation does not affect the quality control tests required by your grading

agency which must continue in the normal way.

Maintaining accuracy depends on controlling long term drift and accuracy of calibration. Metriguard's new (patent pending) Symmetric Bar calibration system eliminates the effects of bar geometry and machine deflection settings and makes possible even more stable operation of the system. By using this system we completely eliminate the need for a calibration against a wood correlation sample, and in the process we eliminate another source of variability in calibration that arises because each new wood sample will give a slightly different calibration result. The more accurate and stable the calibration, the better the grade yields can be because less safety margin is required in the grade threshold settings to account for these variables.

These are some of the reasons that MSR equipment from Metriguard can operate for years on end without going out of control in the QA tests.

Matching the Grade Combination to the Fiber Supply

Not all wood is created equal. [3] Some species will naturally produce higher E and strength values than others. We have seen samples of lumber that produced high percentages of 2.3E 2800F MSR grade and others where not a single stick of a 3-unit test sample had qualities sufficient to make the lowest MSR grade.

One of the great advantages of grading lumber under the American Lumber Standards policy is that the procedures allow for adjustment of the grading process to optimize performance. [7]

We have thought traditionally that a higher lumber grade has higher design properties. But with the introduction of MEL grades, the ability to make MSR grades with different property combinations and considering other machine grading systems around the world it is more useful to define a higher grade as one that sells for a higher price in the market. This way the property most important to the owners, price, can be ordered and grade combinations can be compared in a meaningful way.

Maximizing yield means maximizing the dollar value of the product flowing out of the plant. All other measures are really meaningless. This is where Metriguard's Yield Analyzer comes into play. Yield Analyzer is a computer program that takes as input the measured Average E and Low-Point E of a large sample of lumber, the grade property requirements for each of the MSR grades, and the market prices, FOB plant, for those lumber grades. The program determines the grade yield for each MSR grade in each grade combination and finds the quantity that will go into the residual visual grades. The visual grade component is important because the highest visual grade that can be produced depends on which MSR grade is lowest in the MSR grade combination. The Yield Analyzer then combines the mill selling price with the yield percentages to find the extended value for all the grades in each grade combination. Since getting maximum value is the goal, the grade combinations are then sorted by mill selling price to find the best choices.

Usually there will be a dozen or so choices within a small percentage of one another among the highest value grade combinations. A few of these may involve more than the number of allowed sorts in your equipment setup, and a few may involve such small yields it is not practical to try to make them. These factors will narrow your choices.

Within the range of lumber grade combinations there will usually be a few for which the mill selling value is lower than a straight visual grade mix. This usually occurs when the lowest MSR grade is at or below 1650F 1.5E thus removing from consideration the visual grades at or above #1 or Select Structural. If the value removed from the visual grades is not made up in the value of the MSR grades, then those grade combinations must be rejected.

Metriguard MSR Yield Analyzer

There is information in the literature about why you should match your grade combination to the wood supply and the market, and procedures are described for this matching process. [6] The following describes how the limitations of the previous processes can be expanded so that a much more comprehensive study can be performed.

The Metriguard MSR Yield Analyzer uses as input the Average E, Low-Point E and visual quality level (VQL) for a sample of lumber representing the candidate stock for the mill. To get a comprehensive picture we like to work with a sample size of at least 1,000 specimens of each size.

Sampling Your Lumber

Balanced Sample. Yield testing begins with design of the test sample. We like to start with a record of mill production for a year showing sizes and grades of dimension lumber produced. The test sample should have the same proportions of grades and sizes except we don't normally sample non-candidate stock from utility and economy grades. Next we take unit-sized portions to get close to the matching proportions then either replicate or delete data from enough randomly chosen specimens to match exactly the annual production percentages of grade, size and length in the annual production report.

Balancing the sample has the same effect as taking a mill-run sample, which of course is another possibility for a sampling method. This is normally difficult in the logistics department because we would like to get this sample right out of the trimmer and before any sorting has taken place but with the grade mark in place.

MSR grades range from 1.0E 1200F to 2.3E 2800F in increments of 0.1E. 1.0E means an E value of one million, and so the increments are 100,000 psi between MSR grades in North America. For each of these grades there are corresponding wood design properties for Fb, Ft, Fv, Fc, Fc-perp and E, and this is true for all visual grades and machine grades in other systems such as MEL, MGP, MSG and others.

It is necessary to have a design value for each of the six properties, and where a measured value is not available, a safe one is supplied by the committees that have charge over these matters, in each of the countries where wood is used in engineered applications. I have been using the English system of measurement in this discussion but in most parts of the world the E and strength values are reckoned in metric terms. The conversions are simple and straightforward.

Analyzer limits. Nobody makes all the lumber grades. A practical limit is about 3 MSR grades to be made concurrently together with 2-3 visual grades. So while the Metriguard MSR Yield Analyzer can be set up to examine all combinations, we set up the yield

analyzer to examine all the 1, 2 and 3 MSR-grade combinations from 11 MSR and MEL grades and from this we will examine 211 choices. Grades below 1.5E 1650F are not included because in looking at several dozen situations those lower grades did not work out economically. 1200F and 1400F grades don't work because they dictate a lower visual downfall grade that reduces net value of the mill flow. The Yield Analyzer finds the percentage grade yield in each grade of each grade combination, combines this with price information to find a $/mbf value for each grade combination, including both MSR and visual grades. This seemingly simple task will tie up a high performance PC for more than a half hour making all the calculations.

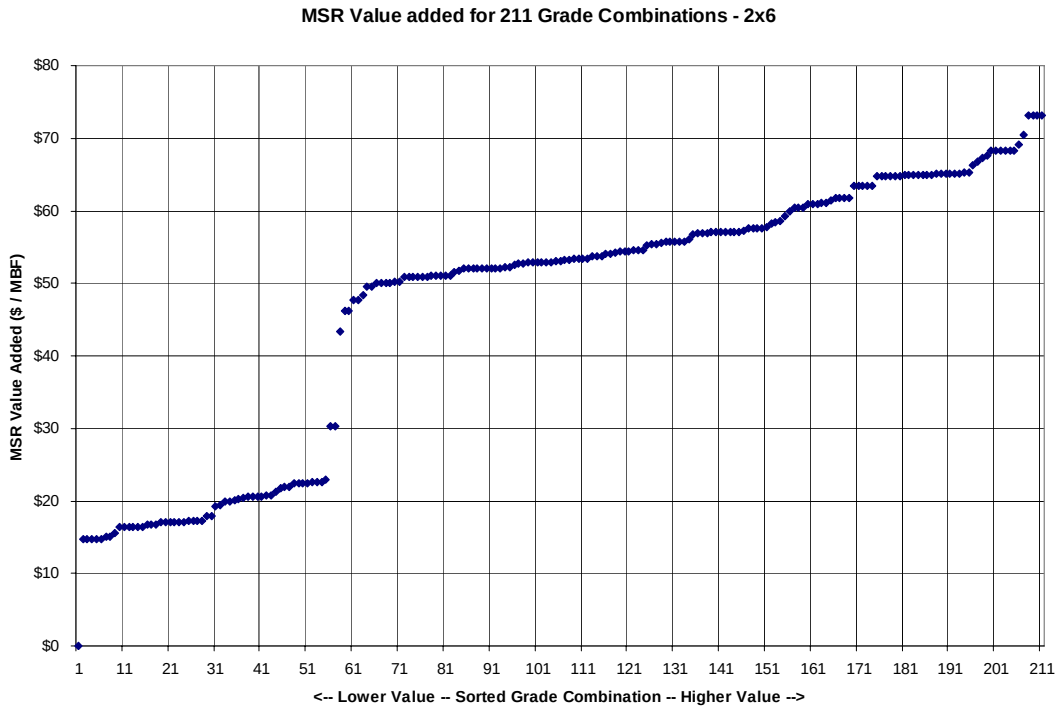

Figure 4. This chart shows the mill selling price uplift or value added available for a group of 211 grade combinations, the value uplift for each grade cobination indicated by a point on the chart. The vertical axis is Value Added by MSR ($/MBF), over and above the visual grade mix being produced at this mill. The grade combinations indicated in the upper right corner of this chart best match the fiber supply to the market, given the market prices that were used as input for this run.

One of the most challenging steps is finding a selling price for all the grades. We use published prices for a few key grades, interpolate and extrapolate to find the missing numbers and then discount unpopular grades. The theory is that any grade will sell at some price. If a price seems high we can reduce it for purposes of the study to a number that we believe will move the goods. Then if, in spite of all that, the grade is part of the winning combination, the one with the highest value, we really should think about making that grade and finding a customer for it.

The number of MSR grades you can make concurrently will be limited by sorting capacity because you will have to find a place for each length of each grade produced. We can run the program for more than 3 MSR grades in combination but most sorting systems won't have the vast number of bins or drops that come out of this kind of extravagance. Also more than 3 MSR grades is usually not practical when you optimize

the yield in the highest grade.

Optimizing profits also involves many other steps that should be taken to ensure that you're not systematically damaging the wood or losing grade because of over-drying, over-trimming, under trimming, scant sawing or quarter sawing so excessive spike knots are present in the lumber.

Accurate planer setup is a must for the MSR market because most of the lumber goes into nail-plate trusses and thickness control is required to get the plate to embed properly in all the mating pieces.

Putting it All Together

We have some more or less disconnected pieces to a full yield improvement program described above, so now we propose a 3-step process for implementing it all for your mill.

1. In the first step our service technicians work with your operators, millwrights and electricians to review your operation of the equipment, fill in any gaps you may have in training, fix any equipment problems or adjustment issues and calibrate the equipment. They will also work with you to bring in the latest equipment updates and get them installed. The final test for completion of this work is a 90 to 100 repeatability test score.

2. The second step involves gathering data and getting it analyzed to learn the properties of the wood fiber resource you are using and learning about the markets you are serving with your product. This is done by gathering a balanced sample of your dimension lumber in the grade proportions you are now producing and running it through your MSR equipment while recording the Average E and Low-Point E values. This lumber is also examined by your visual graders and the VQL is recorded for each piece. The Visual Quality Level (VQL) indicates the maximum MSR grade for which each stick is visually qualified. This, together with the Average E and Low-Point E determines the maximum MSR grade that can be assigned to the piece. Mill prices are then determined for each visual grade being produced and each MSR grade that can be produced at the mill.

   The Yield Analyzer is then used to combine the MSR and visual grade yields with prices to find the value for all potential MSR grade combinations.

3. In the third phase our service and engineering team will work with your management and marketing departments to help work out an implementation plan to install the most promising grade combinations as selections in your equipment, and work with your grading agency to get you certified to produce the grade combinations that best match your fiber resource and your market.

   Your markets will probably change faster than your fiber supply, so part of this process is to provide a computer spreadsheet into which you can enter new lumber selling price information and re-run the optimization for lumber value so you can determine given the new price information if you are still operating near the maximum value point.

In the future as your fiber supply does change, we can repeat steps 2 and 3 at relatively

low cost by having your plant personnel trained in the data collection phase. They would collect the required information, send it to Metriguard for analysis, and we at Metriguard would update the selling value spreadsheet and send it back to you by e-mail.

Metriguard's engineering and service teams stand ready to assist you in making your MSR operation the most profitable it can be. Please feel free to call us any time to discuss these opportunities.

Depending upon where you are with MSR grading, Metriguard can help you determine if you are achieving your grade yield potential. If you are not currently grading with Metriguard equipment, but using some other brand or type of equipment, we would be happy to run a sample of your lumber through our mobile system. We can bring the system to you if you are in the US or Canada, or you can ship a sample of your lumber to us for testing. Depending on where you are located it may be less expensive to ship a sample to us rather than have us bring the mobile MSR system to you.

Figure 5. Metriguard's mobile MSR system can provide an on-site evaluation of your MSR yield potential. This is a self-contained system with its own diesel engine driven 3-phase generator set, and it can be up and running in a few minutes after arriving at your mill site. We can provide this service at a reasonable charge to cover our costs for fuel and labor.

If you really are in this business for the money it would make sense to find out if the Metriguard system is right for you. After running these yield studies we have replaced several systems manufactured by other parties around the world because of better grade yield and better in-control performance. A typical installation takes about ten days for installation, wiring, plumbing, calibration, training and certification by the grading agency. Plant personnel have in every case been capable of taking full charge of the operation of equipment after hands-on training by Metriguard service technicians, and you get free telephone help for any questions that remain after our technicians get on the plane to come home.

The Metriguard equipment is fully assembled, powered, calibrated, tested and run at idle for 24 hours to make sure everything is right before we ship it to you. Our observation is that it costs ten times as much to fix a problem that escapes out the door so we do everything we can to prevent problems at the mill.

Whenever we discover an improvement we can make to our equipment to make it work better, faster, safer or more reliable, we incorporate the change into our production equipment, update all our in-process stock and make the change available to our users

by an announcement in the form of a Service Bulletin.

In 1995 Metriguard introduced its Model 7200 HCLT and a couple of years later Metriguard acquired all remaining parts and supplies for the CLT Continuous Lumber Tester. Now 13 years later we are still selling parts and services for the CLT, the first major MSR work-horse that has been in production for 45 years. Those old machines are difficult to work on and slow by today's standards but they are reliable and accurate and if you have one we plan to help you keep it going as along as parts are available. There are a few parts we can't get anymore, such as digital voltmeters and several other parts used in the electronics. We can replace the electronics with the PCDS2 computer system used with the Model 7200, and we will be coming out with a new revision, PCDS3 that will take the computing side of the lumber grading into the world of Ethernet, remote monitoring with local net cast of your grading results on the plant network.

References

1. "Procedures for Mechanically Graded Lumber", Southern Pine Inspection Bureau, Pensacola, Florida, 1997

2. Special Products Standard for Machine Graded Lumber", SPS-2 National Lumber Grades Authority, New Westminister, BC, Rev 2006

3. Wood Quality… Impact on Product Yields, Grades and Values, Forintek Canada Corp http://www.for.gov.bc.ca/hfp/training/00005/woodqual/wqfwkbk4.pdf

4. Jozsa, L. A., and G. R. Middleton, "A Discussion of Wood Quality Attributes and their Practical Implications", Forintek Canada Corp., Special Publication No. SP-34 ISSN No. 0824-2119, December 1994

5. American Lumber Standard Committee, Incorporated -- Machine Graded Lumber Policy, http://www.alsc.org/greenbook%20collection/UntreatedProgram_MachineGradedPolicy.PDF

6. Galligan, William L., and Kent A. McDonald, "Machine Grading of Lumber, Practical Concerns for Lumber Producers", US Department of Agruculture, Forest Service, Forest Products Laboratorty, General Techical Report FPL-GTR-7, Rev September, 2000, http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr07.pdf

7. Galligan, William, and Donald DeVisser, "Machine Grading Procedures under the American Lumber Standard", http://www.wclib.org/pdfs/WCTE_2004.pdf

History Lesson

1970 – The American Lumber Standards Committee voted to change lumber sizes. 2x4 changed from 1-5/8" x 3-5/8" to 1-1/2" x 3-1/2" and other dimension lumber sizes were changed in a similar way. These changes required all trusses to be re-engineered. http://www.sbcleg.com/common/kb/KB_SingleWebPage.php?KBID=6127&PHPSESSID=2jlrnsj2tkhlmq442qusilam84

- You have been provided a complimentary subscription to Metriguard Messenger if your e-mail is in the Metriguard Inc database and your record is flagged to receive catalogs.
- Please feel free to forward this to anyone within your organization that you feel may benefit from the contents.
- You may add a new subscriber by simply sending us an e-mail message here.
- To inquire about information in this newsletter you may contact us at Metriguard by clicking HERE
- If you wish to un-subscribe from this newsletter you may click here for safe removal
- Link to Printable version of this newsletter (pdf). Back issues are here.

2465 NE Hopkins Court, PO Box 399
Pullman WA 99163 USA
Tel 509-332-7526
Fax 509-332-0485
24 Hour Support Tel 509-332-0554
www.metriguard.com