NON-DESTRUCTIVE TESTING

Mr. Harold Nichols, Irvington-Moore,
Portland, Oregon

"Non-Destructive Testing" is the general title assigned to any test work not resulting in damage to the item being tested. Examples of non-destructive testing would be weighing or measuring a piece of lumber. In this case a very simple test is performed and no damage results, or in other words the test specimen is as well suited for service after testing as it was prior to testing.

Obviously we are interested in more elaborate testing than weights and measures. Our Company has recognized the need for test equipment in this general category of N.D.T. and has provided some tools for the industry. I would like to discuss briefly some of this test equipment today, especially one device called the "E' Computer.

We are presently working in two main areas of N.D.T. as it relates to the lumber industry:

1. Wood Moisture Content, and
2. Wood Strength.

Moisture

Dry Moisture Meter: We have developed, in cooperation with the Weyerhaeuser Company, a continuous, non-contact dry moisture meter. This item is for determining average M.C. along the length of a board or for local spot checking of moisture. It is meant for use in the range of about 8 or 10% up to 25 to 30% and will spray mark the lumber for identification or generate an electrical signal to operate other equipment.

In Kiln Moisture Meter: We are currently working on a device to monitor the moisture content of lumber within the kiln. This item is still in the development stages but should provide good information of the moisture content of a large sample of lumber as it dries below the fiber saturation point. Ability to successfully determine M.C. of a large sample will

provide better control of the kiln. Also it will eliminate more time-consuming means of gathering this data, such as "hot metering".

Strength

Wood Strength: As regulatory agencies tighten their control on building materials and as wood is being looked at more and more as a limited natural resource, we are all forced to make more efficient use of this commodity.

For years no one needed stress-graded lumber. But today, in most markets, it is very important that we establish a more complete set of design properties around our product.

In structural lumber we are concerned with two main properties:

1. Stiffness, and
2. Strength.

The term "f" is a number which represents fiber stress. This is the force, pushing or pulling over a given area, that results from a wooden member being loaded in service. Moreover, it is the highest stress that the member should be subjected to. By using basic formulas the designer or engineer can calculate that a member must have a certain size to withstand a certain load, or conversely that a certain load can be carried by a given wood member.

Two means are available for determining this load carrying quality:

1. Visual inspection based on experience, or
2. Mechanical stress rating.

Most of you are familiar with the inherent limitations of visual grading as it applies to strength. It was for this reason that mechanical stress grading came about ten or twelve years ago. Mechanical stress grading is another form of nondestructive testing.

Most mechanical stress grading determines the strength of a member in an indirect manner. It has been established that a good correlation exists between strength and stiffness and since stiffness is fairly easy to measure, it is this principle that is used to find "f" or extreme fiber stress. If this relationship did not exist, it would be very difficult to determine strength properties.

The stiffness property of a member is referred to as the "Modulus of Elasticity" or simply "E". "E" isn't a strength property at all. You can't use "E" to calculate safe loads. It is only useful, for instance, in predicting how far a beam will deflect under a load "E" is not a single number but is the ratio of two numbers, stress to strain, and has the units of pounds per square inch.

With that as a background then, let us look at some methods for measuring lumber stiffness.

Continuous Lumber Tester: The continuous lumber tester is a precision machine for high production and grades pieces of lumber by deflecting them in both directions in the weak plane and measuring the force required for that deflection. All of this takes place as the lumber is passing through the machine at up to 1, 000 feet per minute. The machine indicates either average "E" along the board length or minimum "E" at its lowest point. It is equipped with a grade stamp device and can stamp the individual boards automatically with their strength grades.

"E" Computer: Another way to measure "E" is by use of the vibration theory. A basic handbook formula for the natural frequency, f, of a homogeneous material is:

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$$

This can be rearranged algebraically and by substitution to:

$$E = \frac{WL^3}{79.13\, bh^3T^2}$$

where W is weight in pounds, L is span in inches, b is specimen width in inches, h is specimen thickness in inches and T

is the time for one vibration (Period) in seconds.

The above formula states that if we wish to know the modulus of elasticity of a homogeneous material and we know the weight of the specimen, its physical dimensions, the length of span between two simple supports, all that is required is to measure the time for one cycle as the specimen vibrates at its natural frequency.

This then is the principle behind the "E' Computer. The remarkable thing is that it does work on lumber which is not a homogeneous material.

The "E' Computer is actually an analog computer and was developed jointly by Irvington and Washington State University. It is primarily a lab or research tool but can be used as a low production machine also.

The "E' Computer measures dynamic modulus of elasticity by the transverse vibration method. A specimen is placed on the supports and vibrated by a tap of the hand. One support houses a load cell enabling us to determine the specimen weight. Other factors such as length, width and thickness are introduced, or scaled, into the computer as voltages. The whole purpose of the "E' Computer is to develop a single voltage proportional to "E" which may be read with an appropriately scaled voltmeter. "E' is readout on a three decade digital panel meter with correctly placed decimal point. The same load cell that weighs the lumber also measures the frequency of vibration and compares it to a known, 60 cycle, oscillator, thus determining the time for one cycle of vibration.

One of the inherent disadvantages in using the "E' Computer as a production tool is the fact that lumber coming to the test area may not all be the same length. Since we were concerned about this we recently conducted some tests to determine the effect of lumber overhanging the far end support. Test results show that the overhang effect is negligible in long lengths, say 18' to 20', if it is kept to 24". Also the tests show that with shorter lumber, say 8' to 10', the overhang effect is no problem if kept to 12".

Two offsetting circumstances prevent this far end overhang from affecting the reading:

1. If the specimen overhangs the far end, the weight measured at the near end is reduced.
2. At the same time the span length is effectively reduced causing a higher frequency of vibration.

The net effect is for these two factors to partially cancel each other.

If we wish then we can provide a series of far end supports that will be spaced not over 12" apart to support 8' and 10' lengths and up to 24" apart for longer lengths. Some switching device must be triggered to determine which support is being used to scale into the computer the correct span length. Used in this manner the computer becomes a production tool capable of about 4 - 6 pieces per minute with two men operating.

Conclusion: The "E' Computer has demonstrated to be very accurate and reliable. In comparison tests with other devices, measuring "E', the computer has probably been the most reliable of all. The Computer is not perfect and no one is more aware of its shortcomings than we are. However, it has proven to be much more accurate than a man estimating "E' visually. As far as f is concerned, "E' is only an indicator of f. We still are not measuring f. The only way you can measure f is to break the specimen. There isn't any other way. We can make some pretty accurate estimates of f and with the "E' Computer (or with other machine grading devices) we have a more direct and reliable way to estimate than with visual methods. We look at machine grading as an additional tool for the grader. Prior to machine grading he estimated strength without any aids. Now he has an additional way to help him make a judgment.