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Section 2 **Test methodology and assessment**

EVALUATION OF VARIABLES THAT INFLUENCE DYNAMIC MOE IN WOOD DECAY STUDIES

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ABSTRACT

The effect of wood moisture content (MC) and outdoor exposure of southern pine lap-joint components on dynamic MOE values was investigated. The use of dynamic MOE as a method of measuring progressive biodeterioration of above ground test samples shows promise, but the accuracy of this method for evaluating test samples subjected to fluctuating environmental conditions has not been reported. The results of this study show that fully water saturated samples had consistently lower MOE values than those obtained at lower MC levels. After the MC was reduced from saturation by about 30%, variation in MOE with changes in MC down to the fiber saturation point were minimal. Outdoor exposure of the test samples also influenced the MOE. After an initial period of outdoor exposure, slightly lower MOE values were obtained for all of the test samples. However, subsequent MOE measurements after additional outdoor exposure were fairly consistent and did not show a trend towards either lower or higher values. For some test samples it was not possible to obtain reliable frequency measurements, resulting in their exclusion from the study.

Keywords: dynamic MOE, wood moisture content, variability, above ground tests

INTRODUCTION

Even though it is generally acknowledged that changes in strength properties is a better measure of wood decay, visual evaluation is still the predominant method used to determine the extent of decay in field tests. One reason for this lack of use is that the equipment required to determine modulus of rupture (MOR) and elasticity (MOE) does not normally lend itself to routine use in field applications. Furthermore, some of these strength tests are destructive and this requires that long term tests must have excessively large numbers of test samples. Consequently, this limits the choice to non-destructive tests based on MOE measurements that are designed to subject test samples to strain levels below the proportional limit to preclude permanent damage. The MOE of wood samples can be determined either by static bending tests or dynamic tests based on measurements of resonant vibration or sound transmission. Static bending tests have limitations on sample size and configuration that provide the appropriate length to depth ratio, whereas dynamic tests can be carried out with a broad range of sample sizes and configuration.

In evaluating wood preservatives in field tests, both ground contact and above ground exposures are used. Field stakes are generally used for ground contact exposure and, as a result of intimate soil contact, the development of decay becomes visible on the surface. Consequently, the visual rating system provides reasonably good estimates of the extent of decay. On the other hand, in lap-joint above-ground tests decay is not always visible on the surface and the visual rating system does not always provide a reasonable estimate of the extent of decay—particularly in the early stages of biodeterioration. Given these considerations it is apparent that the development of alternate methods for evaluating the condition of field test specimens logically should be directed at above ground tests.

On the basis of a number of studies published over the past decade, the use of dynamic MOE (MOE_{dyn}) determined by resonant vibration excitation appears to have considerable promise as a method for evaluating the extent of wood decay in field tests. In an early study by Machek et al. 1997, the potential of using MOE_{dyn} was demonstrated in a fungus cellar test. In this study it was shown that there was a good relationship between mass loss and MOE_{dyn} for hardwood stakes. Furthermore, there was an excellent correlation for the elasticity of sound and decayed wood determined by a traditional static bending method (MOE_{stat}) and $MOE_{dyn.}$ These findings were verified in subsequent studies (Machek et al., 1998A, 1998B, 2001B) for both hardwood and softwood stakes in accelerated soil contact decay tests. In another study by Machek and Militz, 2004, a comparison between MOE_{dyn} and MOE_{stat} for wood samples that had artificial defects (holes and notches) were evaluated. It was found that the location and type of artificial defect influenced the results, but there was an excellent correlation between the two methods of measuring elasticity. The effect of wood moisture content (MC) was evaluated in another study by Machek, et al., 2001A. In this study with Scots pine it was concluded that MOE_{dyn} remained constant at wood moisture contents ranging from 160% to 10%.

In a study that included both fungus cellar stakes and field stakes a poor correlation was found between MOE_{dyn} and MOE_{stat} (Grinda and Goller, 2005). However, despite this lack of correlation between these two methods this study did show that MOE losses due to decay were highly correlated. In a recent study, it was shown that there was a good correlation between radial compression strength loss and a decrease in MOE_{dyn} for southern pine sticks exposed in an accelerated soil contact decay test (Li, et al., 2008). These two studies provide further verification that use of MOE_{dyn} as a method of monitoring the extent of wood decay has potential.

Despite these encouraging results indicating that dynamic MOE is highly correlated to wood decay, there is a need to determine the accuracy of using this methodology in field tests. It appears that a good application of this technology would be for monitoring the extent of wood decay in above ground tests. Accordingly, the objective of this study was to determine the potential impact that variation in wood MC and outdoor exposure of lap-joint wood test samples have on the reproducibility of MOE_{dyn} measurements.

EXPERIMENTAL

Test Apparatus

MOE measurements were made with a Grindo-Sonic MK 4-1 (Limmens-Elektronika N. V. Belgium). The sample supports were placed 33.6mm (0.224 x length of sample) from each end of the sample. Immediately prior to testing each sample was weighed on a balance. Several frequency measurements were made for each sample, with data from only those samples that produced uniform frequency values being recorded.

Variability in repeated MOE_{dyn} measurements

The test samples were modified lap-joints prepared from flatsawn (maximum variation 15 degrees from true radial/tangential orientation) southern pine (*Pinus* spp.) sapwood boards. Each lap-joint consist of three pieces cut from a single block measuring 27 x 55x 200mm (R x T x L).The initial step in sample preparation was to cut the block lengthwise into two 12mm thick by 55mm wide pieces. Following this, one of the pieces was cut lengthwise producing two pieces 27mm wide. The test units were held together as a single unit with PVC pipe sleeves which were cut from 1 inch PVC pipe by cutting a section lengthwise from one side (Fig. 1). A total of 10 lap-joints were prepared, five of which were vacuum/pressure treated with ACQ-D to a target retention of 4.0 Kg/m^3, equilibrated in plastic bags for seven days and then air dried.

Prior to initiating the MOE_{dyn} tests, the test samples were saturated with water by pressure treatment, then allowed to air dry until the MC was reduced by approximately 50%. The samples were then stored in plastic bags for 24 hours, removed and tested for MOE_{dyn}. The two small pieces were tested in both the radial and tangential directions and only in the radial direction for the larger piece. This procedure was repeated until four replicate MOE_{dyn} values were recorded, with these being averaged to provide the initial MOE_{dyn} value. Following this, the three pieces were assembled into lap-joints and exposed outdoors on a concrete block pad equipped with a fine mist spray system that applied water to the samples twice per week. After 2, 4, 6, 8 and 10 weeks exposure the samples were returned to the lab, placed in plastic bags for 24 hours prior to MOE_{dyn} measurements. A duplicate MOE_{dyn} measurement was made for each sample after allowing them to equilibrate in plastic bags for approximately 24 hours.

Effect of wood MC on MOE_{dyn}

Wood samples identical to those described above were used for determining the effect of MC on MOE_{dyn}, with measurements being made in the radial direction. The samples were saturated with water by vacuum/pressure treatment prior to the initial MOE_{dyn} measurement. Following this the samples were allowed to air dry until the MC was reduced approximately 20%, equilibrated in plastic bags for 24 hours and then evaluated for MOE_{dyn}. This procedure was repeated until the MC was reduced to around the fiber saturation point.

RESULTS AND DISCUSSION

Although the possibility of utilizing dynamic MOE in wood decay studies has generated considerable interest, it still has to be demonstrated that it is an accurate and reliable method. A certain amount of variability is inherent in all methods used to detect and quantify the extent of decay in wood test samples. In this study the variability in MOE_{dyn} measurements attributed to changes in wood MC, as well as outdoor exposure of test samples, was investigated. The practicality of wood decay detection and measurement methods in field trials is enhanced if the variation in wood MC does not have a significant, or at lest minimal, influence on accuracy. In this regard, the data in Figure 2—which is representative of all of the test samples—shows that the wood MC variation does have some influence on the MOE_{dyn} values for lap-joint components tested throughout the wood MC range from full saturation (130%) to a lower level near the fiber saturation point. From this data it is apparent that the biggest increase (2.2%) in MOE_{dyn} occurs during the incremental MC decrease from 130 to 120%. After this, further reduction in MC has only minor effects on the MOE_{dyn}, which appears to be due to normal experimental variation. Consequently, this data indicates that as long as the fully saturated MC condition is avoided reasonably accurate MOE_{dyn} measurements can be made.

Another potential factor that could have an effect on the accuracy of MOE_{dyn} measurements is the effect of outdoor exposure conditions where the wood samples are subjected to wide MC fluctuations resulting in shrinking and swelling cycles. The data in Figure 3, representing the average of 10 lap joint components tested in the radial direction, shows that there is a decrease of 7.6% in MOE_{dyn} for subsequent measurements after the initial mean value was established for the unexposed units. It is also apparent from this data that after this initial decrease, only slight non-significant changes in MOE_{dyn} are apparent for subsequent measurements. As a consequence, on the basis of this data it appears that one should be able to obtain reasonably consistent MOE_{dyn} values after the test samples are subjected to a fairly short term exposure which would occur long before the onset of MOE_{dyn} reductions as a result of decay.

Another observation in this study was that in testing these samples it was not possible to obtain reliable frequency values with the Grindo-Sonic unit for all of the samples in this study. Tests on some of the components produced widely fluctuating frequency values which made it impossible to record a reliable value needed to establish the MOE_{dyn}. In some cases accurate frequency values were obtained when the samples were tested in one direction (tangential or radial) and not in the other direction. Overall, it was found that measurement in the tangential direction generally produced more reliable values than for those tested in the radial direction.

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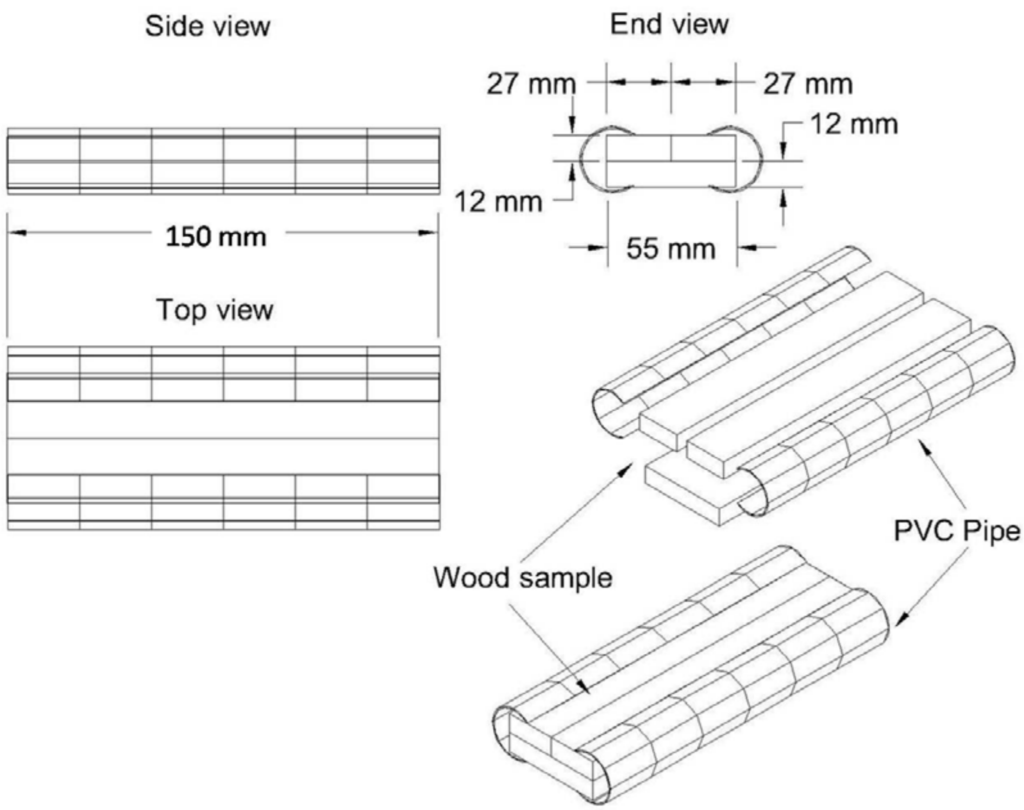
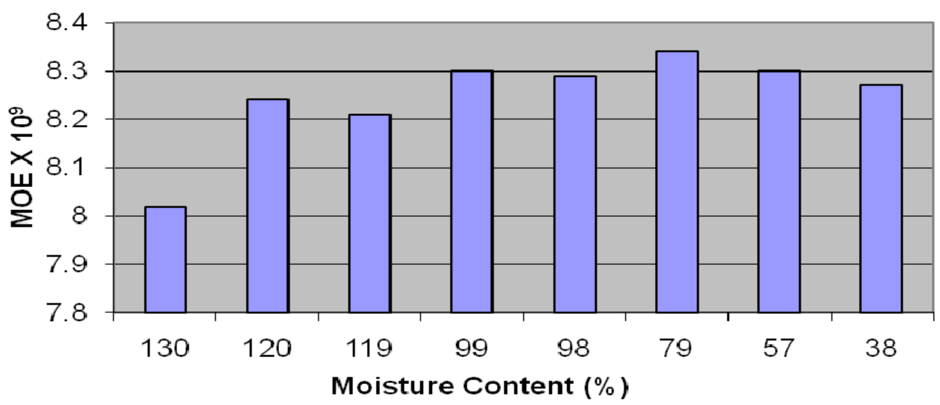


Figure 1. Drawing of 3-piece lap-joint.

Figure 2. Effect of moisture content on dynamic MOE of southern pine



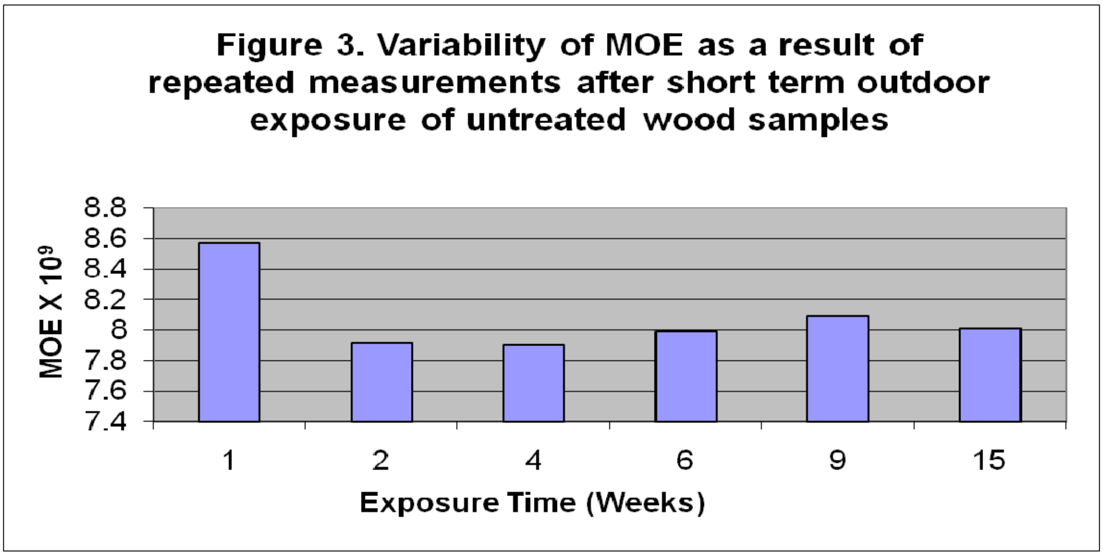


Figure 3. Variability of MOE as a result of repeated measurements after short term outdoor exposure of untreated wood samples
MOE X 10^9
8.8
8.6
8.4
8.2
8
7.8
7.6
7.4
1
2
4
6
9
15
Exposure Time (Weeks)