TECHNICAL NOTE

A MINIATURE MECHANICAL APPARATUS AND TEST PROTOCOL FOR BENDING AND CRUSHING TESTS IN WOOD PRESERVATION RESEARCH

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ABSTRACT

A miniature mechanical test apparatus for determining the modulus of elasticity and crushing strength of small wood specimens has been developed. This apparatus provides a sensitive method for laboratory studies to measure both soft-rot and basidiomycete decay in wood test samples. Test results show that progressive soft-rot attack can be accurately measured by changes in modulus of elasticity. Tests on use of the apparatus to monitor the amount of basidiomycete decay in soil block tests are underway.

A major problem with most laboratory wood preservative evaluation methods is the lack of an accurate methodology for determining the extent of decay in wood test specimens. Mass loss after exposure to wood decay fungi is frequently used, but this method suffers from poor sensitivity and the inability to detect wood decay in the early stages. This insensitivity is particularly true for soft-rot decay, but also applies to basidiomycete decay.

Research has shown that wood deterioration by decay fungi adversely affects the mechanical properties of wood (1,4,5). The deterioration/property loss relationship could be used in cost-effective and accurate evaluations of wood preservative performance or in nondestructive evaluations of small wood samples for wood structures in service. Some wood protection research is currently focusing on finding ways to use short-term laboratory tests to predict long-term performance of wood under conditions of actual use (2,3).

A previous report (3) described a bending-test apparatus that showed promise as a method for determining soft-rot decay in wood. Although the apparatus was crude, it did establish the principle of this method. Subsequently, a more accurate apparatus was designed and built. After further refinement, a second apparatus was developed that has the capability of measuring the crushing strength of wood. Determining the crushing strength of wood in the radial direction is an excellent measure of basidiomycete attack and should be a good method of evaluating decay by these fungi (5-8).

This paper describes the bending-test apparatus used for both bending and crushing tests and provides some preliminary bending test data. No crushing test data are available but will be forthcoming in the near future.

DESCRIPTION OF THE BENDING-TEST APPARATUS

The apparatus is specially designed for measuring the modulus of elasticity (MOE) in small wood samples (Fig. 1). A two-phase hybrid stepping motor and a transducer (loadcell) are integrated into one convenient high performance unit. The stepping motor is used to position a loading head. The transducer (loadcell) measures the loading force and determines the loading head position. The contact position between the loading head and the wood is crucial in bending small wood specimens because it affects the deflection of the specimen during bending. Using a predefine load or position is not satisfactory because they may change during the decay process. Moreover, it is difficult to accurately control the dimensions of the wood samples. A movable cooper block on the loading head functions as a switch to indicate when contact is made with the test sample. When contact occurs, an electrical signal is sent to the computer to start the bending test. The

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wood sample is deflected to a predefined position, and the loadcell measures the resultant bending force. The position is maintained for a specified amount of time (35 seconds in current tests), during which the bending force applied to the load head gradually decreases due to stress relaxation in the wood. This decrease in bending force is monitored throughout the specified time period and recorded by the computer with the data-acquisition system.

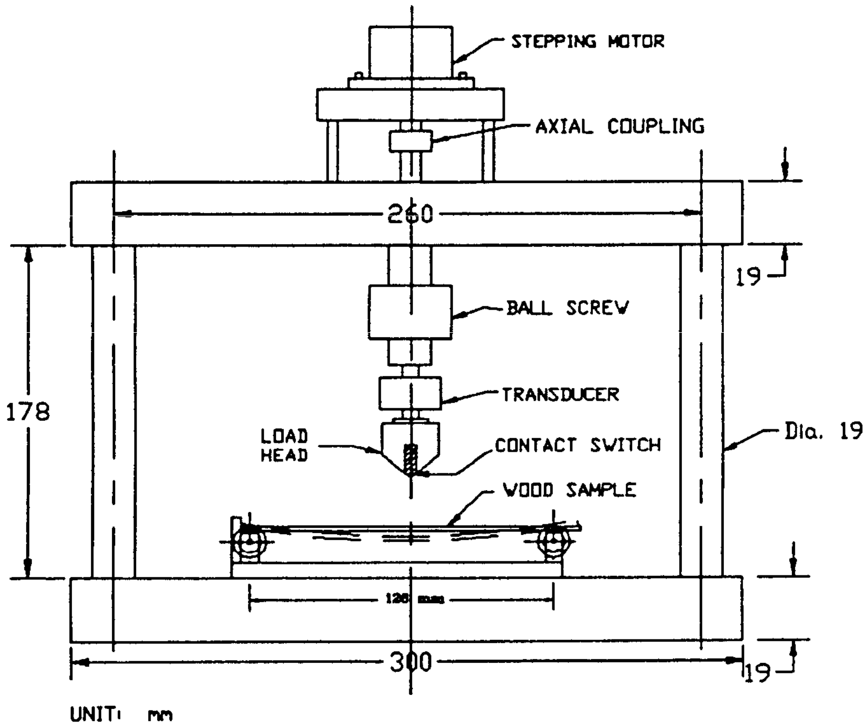

Figure 1. — Schematic of the bending test apparatus.

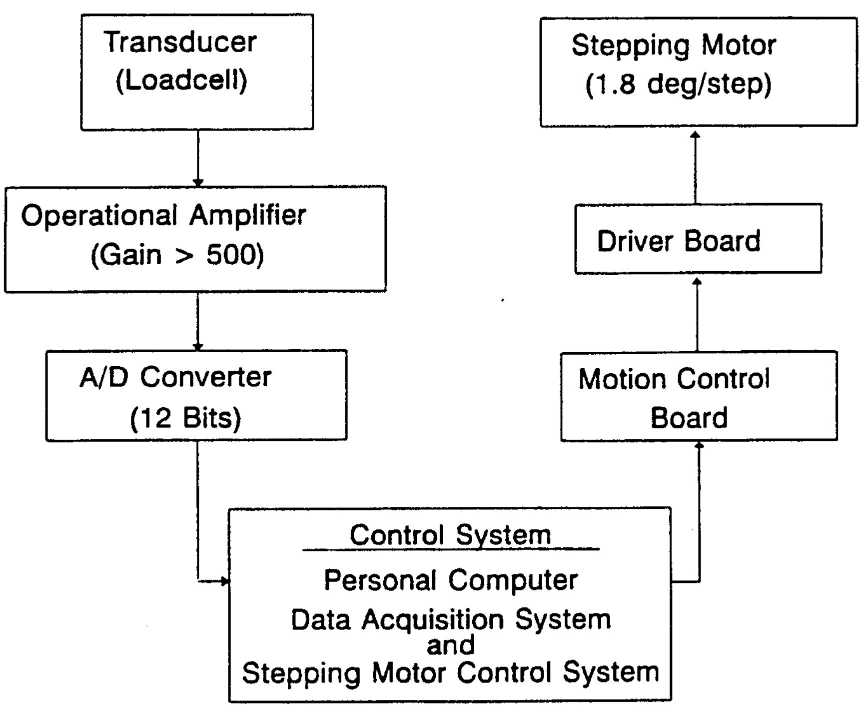

Figure 2. — Control sequence chart for the test machine.

The whole unit is controlled by a personal computer through a stepping motor and data-acquisition system with specialized software. The control sequence chart is shown in **Figure 2.**

The stepping motor runs at full step mode (400 steps per rotation). The positioning resolution of the loading head is 0.0127 mm/step. The capacity of the transducer (loadcell) is 0 to 11,350 g (25 lb.).

TEST PROCEDURES

For soft-rot decay tests, test specimens measuring 3 by 19 by 150 mm (tangential by radial by longitudinal) were selected because thin specimens show a rapid response to decay. The specimens need to be saturated with water and tested wet to eliminate the need to equilibrate them to an equilibrium moisture content before testing. After the test specimen is placed in the apparatus, the test procedure consists of three steps: 1) the loading head moves down and contacts the test specimen, which is detected by the switch on the head; 2) the test specimen is deflected exactly 2.5 mm and the maximum load is recorded; and 3) the load head returns to the starting position.

The predefine speed profile of the stepping motor involves five stages: ramp → slower speed → fixed speed → stall → ramp. Load data readings are taken each second and stored on the computer disk.

Measurement of the crushing strength of wood for basidiomycete decay tests requires a different load head on the apparatus. The crushing strength load head is cylindrical in shape and has a high capacity loadcell (90,800 g). The test specimens should consist of wafers measuring 5 by 19 by 19 mm (longitudinal by radial by tangential), which are loaded in the radial direction. Use of this size specimen accelerates decay and minimizes the time required to carry out the test. Because the wood is permanently damaged when crushed beyond the proportional limit, either end-matched wafers or wafers pretested to the proportional limit must be used to establish the initial crushing strength. The technical parameters of the apparatus are the same as the bending test, but the test procedure is different. Three points on the stress-strain curve are defined as stop points for completing wood crushing. Such points are evaluated as indexes for the relationship of compression strength with decay. Before every batch test, the press head is calibrated to touch the base plate, then the head is moved back 22 mm above the plate to define the head position. The calibration procedure is automatically executed by the computer and is an option in the control software.

TEST METHOD EVALUATION

In a 1994 study, Crawford (2) carried out a series of experiments to optimize the operating procedures for the bending apparatus. This study demonstrated that the optimum deflection was 2.5 mm for southern pine *(Pinus* spp.) test specimens. Lower deflection levels resulted in a higher standard deviation for the replicate test specimens, and greater deflection levels exceeded the proportional limit **(Fig. 3).** The rate of loading was also evaluated. Within the tested range (60 to 100 mm/min.), the loading rate did not affect the accuracy of the measurements. Hence, the test time can be reduced by operating the machine at the higher speed.

Tests show that the bending apparatus is capable of making reasonably precise load measurements. The standard deviation for repeated measurements on wood specimens has been shown to be ±0.35 percent (2). Consequently, the apparatus is capable of detecting small differences in soft-rot decay.

Possible uses of the stress relaxation data generated in this test are also being evaluated. Because stress relaxation is a dynamic measurement, it may have potential for increasing the sensitivity of the test during the incipient stages of decay. A typical stress relaxation curve for a southern pine test specimen before and after 10 and 20 weeks of exposure in a soil bed is shown in **Figure 4.** As expected, there is a decrease in the maximum load due to soft-rot decay. In addition, there is a change in the slope of the curve up to the maximum load. The significance of this change in slope is not known, but it may provide an alternate method of determining the extent of decay. This aspect of the test method will reevaluated in future studies.

The apparatus' ability to measure the crushing strength of wood may be applicable to basidiomycete decay tests. This method of evaluating basidiomycete decay is appealing because it may provide a more sensitive means of detecting the extent of decay, particularly in the incipient stage. Furthermore, by using 5-mm wafers and testing wet samples, which eliminates the need to equilibrate them before and after the decay test, the overall test time can be reduced significantly from that

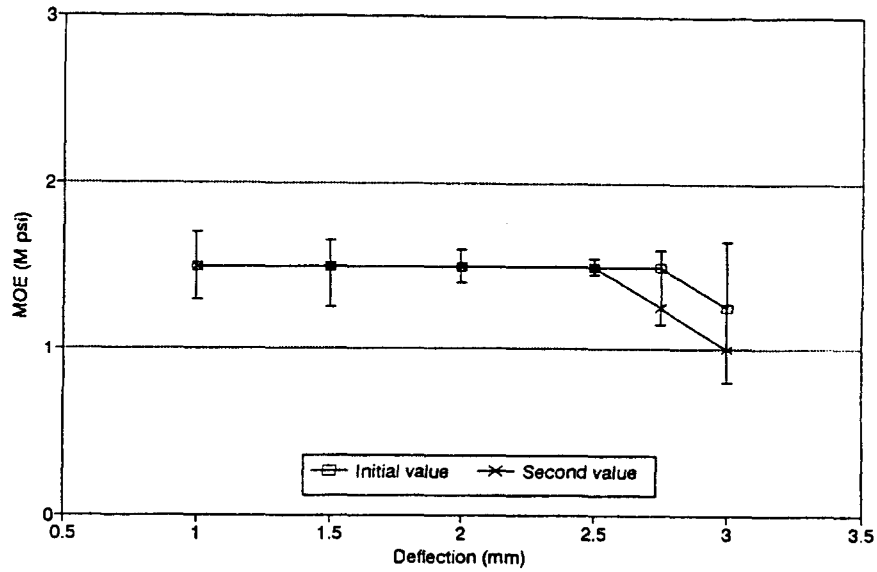

Figure 3. — Average change in modulus of elasticity as a function of known deflection for an average of 10 stakes tested 1 hour apart (range indicated by brackets; rate of loading = 105.4 mm/min.).

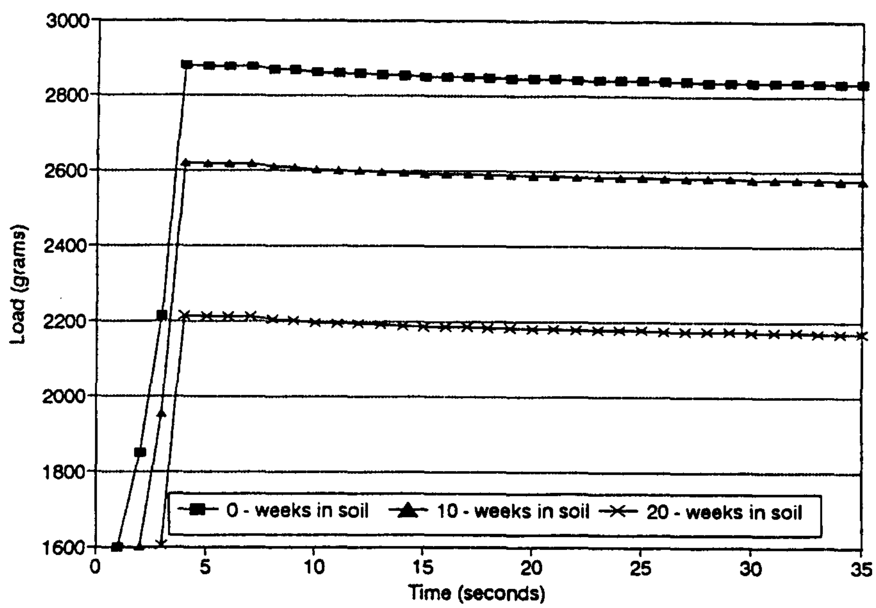

Figure 4. — Typical load values and stress relaxation of test specimens before and after exposure in unsterile soil.

required for the normal soil block test. Evaluation of the crushing strength method is in the early stages, and the **results** will be reported at a later date.

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