MONITORING ACOUSTIC EMISSIONS TO PREDICT MODULUS OF RUPTURE OF FINGER-JOINTS FROM TROPICAL AFRICAN HARDWOODS

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ABSTRACT

The acoustic emission patterns generated from bending tests of finger-joints from three tropical African hardwoods, Obeche (*Triplochiton scleroxylon*), Makore (*Tieghemella heckelii*), and Moabi (*Baillonella toxisperma*) were evaluated to determine the possibility of using them to predict finger-joint modulus of rupture.

The patterns of acoustic emissions generated from the bending tests were observed to differ, depending on the type of finger profile and wood species. The regression coefficient of the regression of cumulative acoustic emission count on applied stress squared also varied with the profile and species type. When modulus of rupture was correlated with this regression coefficient, for stresses applied up to 50% of mean ultimate strength, the logarithmic regression model developed could predict modulus of rupture of the finger-joints accurately to ±10%, ±12%, and ±21% for Obeche, Makore, and Moabi, respectively. The models developed also seemed sensitive to the quality of the finger-joints from the three tropical African hardwoods.

The results of the study gave an indication that this acoustic emission monitoring procedure could be useful for nondestructively predicting modulus of rupture of finger-joints from the three tropical African hardwoods.

Keywords: Acoustic emission, finger-joints, tropical African hardwood, modulus of rupture.

INTRODUCTION

The need to set up finger jointing plants to efficiently utilize the enormous volume of trim ends and other lumber residues generated in sawmills in Ghana and other tropical lumber-producing African countries has been expressed several times (Prah 1994; Ofosu-Asiedu et al. 1996). This is not only an opportunity for a mill to upgrade waste and improve return on low-grade lumber, but also a means to promote the efficient utilization of tropical timber.

A finger-joint, which is a type of structural end joint, is said to be one of the most economic ways of wood utilization. By finger jointing, low-grade timber is used to produce

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high quality finished products with improved strength and appearance through the removal of undesirable characteristics (Strickler 1980; Kohler 1981; Fisette and Rice 1988; Ulasovets and Makerova 1988; Beaulieu et al. 1997). According to Lembke (1977), finger-jointed studs commonly bring premium prices because they are straighter and dimensionally more stable than solid studs.

Although classic static tests are considered as more desirable evaluation methods for the mechanical properties of structural timber, they are sometimes difficult to perform and are time-consuming. Fast, reliable, and easy-to-use nondestructive methods for predicting finger-joint strength properties will not only offset the above difficulty, but also go a long way to promote the efficient utilization of mill residues. Nondestructive wood testing permits wood properties of individual timber pieces determined destructively to be correlated with other wood properties measured nondestructively in order to assign property values without damage due to overloading, thereby improving the efficiency of timber utilization (Bodig and Jayne 1982).

Acoustic Emissions

Creation of fracture surfaces in adhesive joints under load causes release of strain energy in the region of the advancing crack. This generates elastic waves, called acoustic emission (AE), created by sudden increases in defect size during the process of loading to failure (DeBaise et al. 1966; Noguchi et al. 1986; Suzuki and Schniewind 1987; Rice and Skaar 1990). Although AE originates with initial fracture, it is commonly considered nondestructive at that stage (Hartbower et al. 1972; Porter et al. 1972; Dedhia and Wood 1980; Ansel 1982). Dunegan and Harris (1968) were among the first to realize that the AE process could be developed into a valuable nondestructive test technique for structures or components of structures. According to Porter et al. (1972) and Knuffel (1988), fractures develop in three distinct phases: initiation, growth, and ultimate failure. In the opinion of the authors, it is useful to consider failure not as a single event in time but rather as a developing process, beginning with the first application of stress on a structure. According to the authors, for a heterogeneous material such as wood, one need not be concerned with this first stage of flaw initiation, as any large wood component will contain a number of potentially damaging inherent flaws. The second stage of the failure process is the flaw growth phase, in which some of the flaws continually increase in size until one of them reaches a critical size for the imposed stress condition, leading to ultimate failure-the sudden propagation of a crack through the structure. The authors reported that fracture growth in lumber commences at very low stress levels, increases slowly at first, and then at a certain point "takes off" rapidly, escalating in frequency and extent until failure takes place. Chistensen (1962) using relatively unsophisticated electronic equipment was able to detect small cracks growing at loads as low as 25% of failure stress, and currently AE activities in some materials can be observed at much lower stress levels using modern equipment. DeBaise et al. (1966) reported that the strain energy or stress waves released are, in most cases, caused by a shift in a local defect area, sometimes called micro-checks, and arise from local stress concentrations in nonhomogenous materials. Other known reasons for the production of AE include material dislocations, phase changes, or the growth of cracks (Rice and Skaar 1990). As a material is stressed, the resulting AEs produced at the defect site propagate throughout the material, and are usually detected by a sensor or transducer attached directly to the surface being monitored (Porter et al. 1972; Dedhia and Wood 1980; Honeycutt et al. 1985; Rice and Skaar 1990). The sensor converts the incoming signal to an electric impulse, which is amplified and conditioned to remove extraneous noise. Many systems in current use allow the emissions to be filtered such that only signals (termed "counts" or "event-counts") above a certain