INTRODUCTION

Wood is the source of structural fiber for use in many different ways. It is a renewable resource, plus, many wood products are recyclable. In the current controversy over the forest environment, it is easy to lose sight of the fact that the worldwide environment includes critical wood fiber usage for shelter, for communication media, and for hygienic products. Since its beginning, research on nondestructive testing of wood has had the goal of increasing efficiency in the use of the wood resource. Today, this goal is more important than ever.

The purpose of this paper is to provide an overview of the major elements of nondestructive testing of wood and also in tracing the developments of wood over the last 30 years. Critical future needs are noted and a short bibliography that contains the proceedings from the Symposia on Nondestructive Testing of Wood as well as several workshops are provided.

THE NATURE OF WOOD

Wood is a material which, aside from trimming here and there and drying, often is used exactly as it has been cut from the tree. No smelting, no catalytic polymerization, no alloying, no fundamental alteration of nature’s wood fiber is required to produce the basic structural form of wood. Wood in this natural form has been used as a structural product for thousands of years.

What are the features of wood that bring about its high strength-to-weight ratios, yet also produce anisotropy and variability? Both the macro and also the microstructure of wood provide relatively easy answers. The familiar cross-section of a tree (Figure 1) illustrates a few of the reasons for the variability. Starting at the center, or pith, the tree grows outward, adding a “growth ring” each year. This growth ring usually is composed of two types of cells: spring or earlywood (formed in the period of rapid growth in the spring) and summer or latewood (formed in the period of slow growth, usually in the summer). These two types of cells have different densities and properties and the ratio of earlywood to latewood often differs year by year. Further, the quality of the wood formed near the pith will be less than that found some 10 to 20 rings further out. Also shown in the figure is the cross section of a
limb that originated at the pith and will appear as a knot when lumber is sawn from the log. This knot can be a significant source of weakness in a product.

The basic structural element of wood is the fiber. A bundle of these fibers is shown in Figure 2 to illustrate the microstructure of a coniferous wood. The majority of the fibers are long and narrow, generally aligned longitudinally with the tree trunk. The high tensile and compressive strength of wood results from this alignment, while the transverse properties, as could be predicted, are much lower. The tubes (fibers) are held together by an adhesive (lignin), completing nature’s composite.

The wood in a tree has a generally circular macrostructure, while at a micro level the structural orientation emphasizes the longitudinal fibers, it is from these fibers that anisotropy results. Further, it is virtually impossible to reduce this complex structure to a product (through cutting, peeling, or pulping) without disturbing nature’s efficiency. As a consequence, much of the wood that nondestructive testing (NDT) addresses deals with the heterogeneity, including knots and similar features, as well as the anisotropy as it affects the performance of the final product.

DEVELOPMENT OF NDT OF WOOD

Nondestructive Measurement of Wood Characteristics

As noted, wood is heterogeneous, containing knots and other characteristics that are considered attributes in some products, defects in others. One thrust of NDT in wood, as in other materials, is the detection and quantification of these characteristics. An important example of this is in producing “cut stock” or wood for the furniture industry. Commonly, knots are allowed in only very limited size and frequency. Acceptable wood must be obtained by identifying the knots and cutting an acceptable piece that excludes the knots. In other processes, distinctive patterns of grain and knots are desirable and must be identified for subsequent processing.

Fig. 1. Cross section of a tree to illustrate the form of the annual growth rings and the presence of a knot

Fig. 2. A drawing of the microscopic structure of a coniferous tree