Determination of Global Modulus of Elasticity of Timber by Using Fiber Orientation and Proportion of Latewood

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Mechanical properties of timber depend on the fiber orientation, the percentage of latewood, the distribution of knot, etc. [1-4]. However, the fiber orientation and the modulus of elasticity (MOE) may be affected by the presence of knots. Therefore, the tracheid effect and proportion of latewood were used in this paper to measure the fiber orientation and MOE of timber, respectively. Since Japanese Cedar (*Cryptomeria Japonica*) is a popular species in both Taiwan and Japan, its timber was used as the test specimen.

By using the tracheid effect, the fiber orientation can be determined from the ellipse formed by the scattering pattern [5]. The in-plane fiber orientation can be determined by the orientation of the ellipse. On the other hand, the out-of-plane fiber orientation angle can be determined from the ratio of the major and minor axis of the ellipse.

In the past, majority of research work used the statistical average material properties obtained from a number of experiments. Since wood is a composite material in nature, based on the rule of mixtures [6], material properties of timber can be calculated by the proportion of latewood and MOEs of earlywood and latewood. Digital image analysis (DIA) technique first reported in [2] was employed to determine the proportion of latewood and earlywood of the radial cross-section.

Functions of digital image processing of MATLAB [7] were employed to determine the major axis, the minor axis, and the orientation of the ellipse formed by the scattering pattern. The stiffness matrix was calculated by the compliance matrix and the fiber orientation matrix. The fiber orientation matrix was combined with the compliance matrix to calculate the global MOE [8]. A four-point bending test was also conducted in this paper to measure the global MOE and the three-dimensional digital image correlation (DIC) method software, VIC-3D [9], was used to analyze the surface deformation during the experiment.

Based on the tracheid effect, an optical setup was proposed in this paper to analyze the ellipse formed by the scattering pattern to determine in-plane and out-of-plane fiber orientation angles. Moreover, the digital image processing technique was adopted to measure the proportion of latewood and earlywood of the radial cross-section. Finally, the global MOE of timber obtained from calculation and experiment were compared and discussed.

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