Elasticity Modulus in Peruvian Tropical Woods Using Non-Destructive Techniques –Preliminary Study

Patricia Inés Carnero Palacios *
Luis Yoza Yoza*
Moisés Acevedo Mallque*
Julio Arakaki Kian*

* Universidad Nacional Agraria La Molina. Lima Perú

THE OBJECTIVE: Evaluation of the efficacy of non-destructive methods to evaluate wood elastic properties (MOE) of diverse species of woods found in the Peruvian rainforest.

The elasticity modulus was determined based on the measurement of transverse vibration frequencies and time of sound propagation.

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Two ultrasound wave propagation equipment were used, the Fakopp microsecond sound velocity measure timer (23kHz) and the Fakopp ultrasonic measure timer (45 kHz).

It was found that elasticity modulus obtained with non-destructive and destructive testing presented high and positive correlation coefficients, which indicates that they have high potential of use for testing the diverse species of woods found in the Peruvian rainforest.

MATERIALS

This study was conducted in the laboratory of technological testing of Wood, in the Forestry Faculty of National Agrarian University La Molina Lima Perú.

Study samples (30 samples)

Group I: Density less than 0.30 g/cm3

Ficus americana, *Annona duckei*, *Cavanillesia umbellata*, *Croton matourensis*

Group II: Density from 0.30 g/cm3 to 0.40 g/cm3

Apeiba membranaceae, *Jacaranda copaia, Simarouba amara*, *Vochysia lomatifolia*, *Schefflera morototoni* (sacha cetico).

Group III: Density (A) from 0.41 g/cm3 to 0.60 g/cm3

Unonopsis floribunda, *Xylopia nítida*, *Matisia bracteolosa, Guarea kuntiana*, *Sterculia frondosa*, *Cedrelinga cateniformis*, *Clarisia racemosa*, *Dacroides nitens*, *Ocotea fragantisima.*

Group IV: Density (H) from 0.61 g/cm3 to 0.75 g/cm3

Naucleopsis glabra, *Caryocar glabrum*, *Diplotropis purpurea, Tetragastris panamense*, *Aspidosperma rigidum*, *Chrysophyllum prieurii, Brosimum potabile*, *Apuleia leiocarpa*, *Licania elata*

Group V: Density higher than 0.75 g/cm3

Dipteryx micrantha, Tabebuia serratifolia, *Aspidosperma schultesii*

Samples were prepared in the dimensions of 2.5 x 2.5 x 41 cm according to the Peruvian Technical Standard Nº 251.017 for static bending tests.

EXPERIMENTAL PROCEDURE

The three method were applied to each sample

1.- DYNAMIC TRANSVERSAL BENDING

This test was performed using the FFT Analyzer. In order to estimate the modulus it was used the following equation.

$$E = \left[\frac{2 f_n}{\gamma_n \pi} \right]^2 \frac{mL^3}{I}$$

Where: E is the elasticity modulus in transversal vibration (N/m^2); f_n is the frequency of vibration of the sample; n is the vibration mode in free free extreme conditions (n=1, 2, 3…); γ_n = (n + 0.5)^2; it n=1 γ_1=2.267; m is sample's mass, L is sample's length and I its moment of inertia. Fakopp (2005)

2.- LONGITUDINAL STRESS WAVE METHODS

Longitudinal stress wave methods were performed with Fakopp Microsecond Timer (23kHz) and Ultrasonic Timer (45kHz) equipments by measurement the time propagation of the wave generated with a ultrasonic crystal, and the distance is between the two sensors, we get the velocity using the following equation,

$$V^2 = \frac{Y}{\rho}$$

Where V is the velocity of the stress wave, Y is the longitudinal elasticity modulus (Young Modulus) and ρ is the density of the wood (measured in kg m^{-3}). Fakopp (2005)

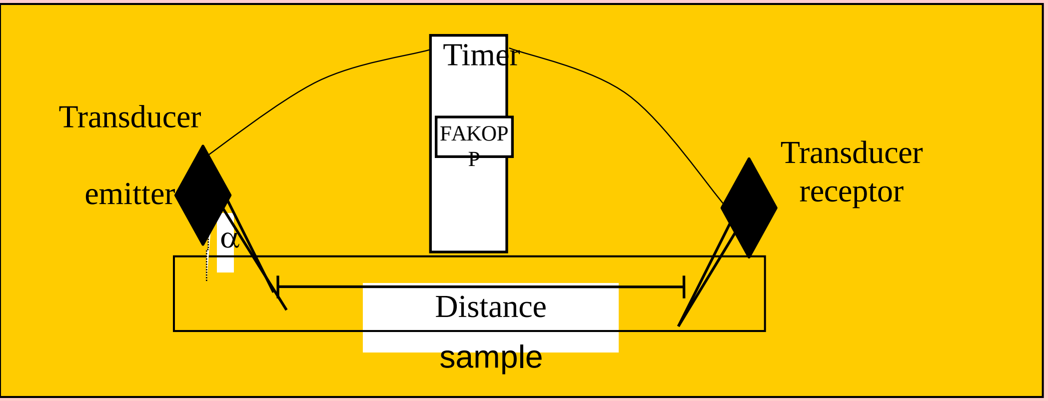
3.-STATIC BENDING

For the static bending method a TINIUS OLSEN universal testing machine

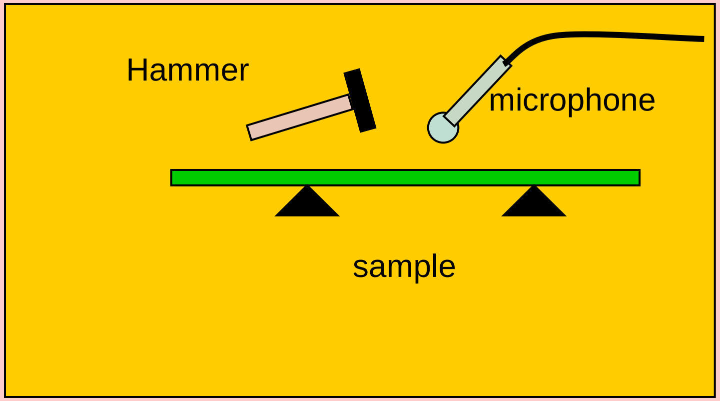
$$MOE = \frac{(P' L^3)}{(4ae^3 y)}$$

where MOE is Elasticity modulus (kg/cm²), P´ is the force at the proportional limit (kg), L is the beam spam (cm), a is the sample´s width (cm), e is the sample´s thickness (cm) and y is the deflection at load point. After all tests were performed it was determined the density and the moisture content of each sample.

Longitudinal Stress Method



Dynamical Transver Bending



RESULTS AND DISCUSSION

Figures 1, show the relationships between the elasticity modulus determined by speed propagation time and wood density, using the microsecond timer with high correlation with a deermination coefficient of 0.8744 And on the other hand, we also found a high correlation of 0.867 for ultrasonic method. This high correlation results as consequence that the samples were very uniform, without knots and interlocked grain, confirming it's directly dependence with the density of wood samples.

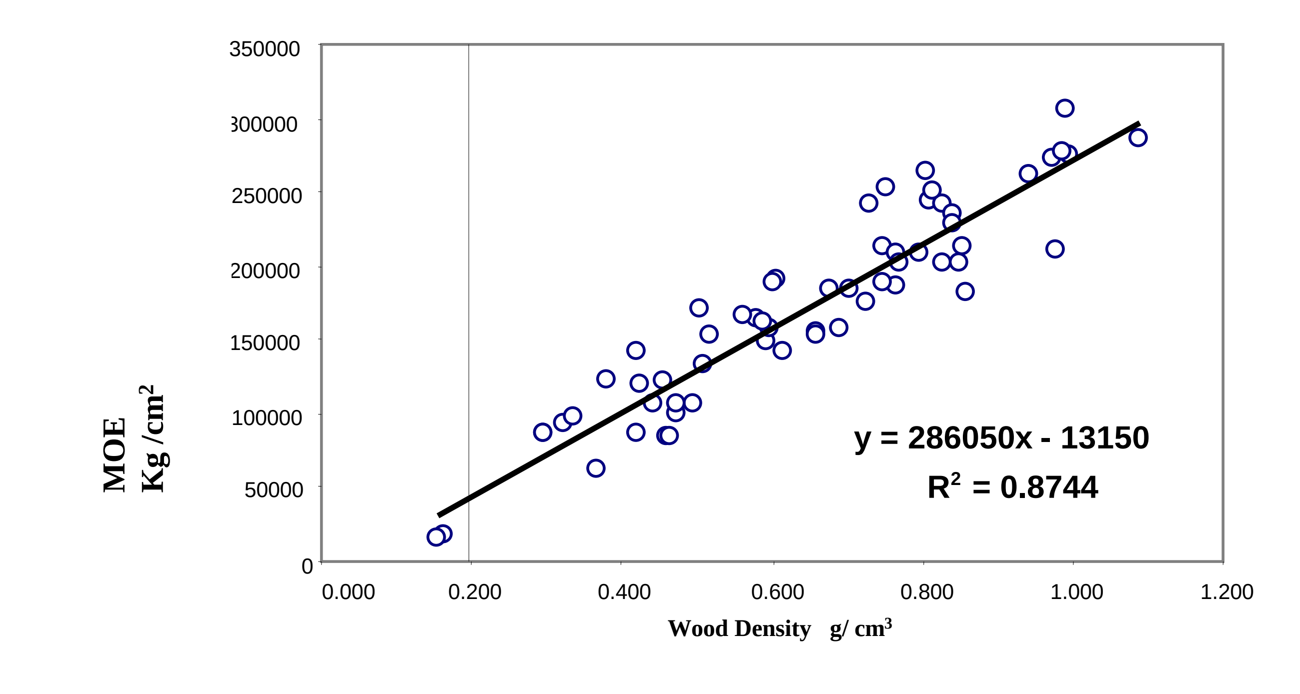


Figure 1.- . MOE (Microsecond Timer) vs. Density MOE

Relationships between destructive and non-destructive elasticity modulus

Figures 2, Shows the existing relationships between the destructive method (static bending test) and the elasticity modulus calculated by using a stress-wave speed propagated by an induced mechanical impact produced by the ultrasonic equipment.

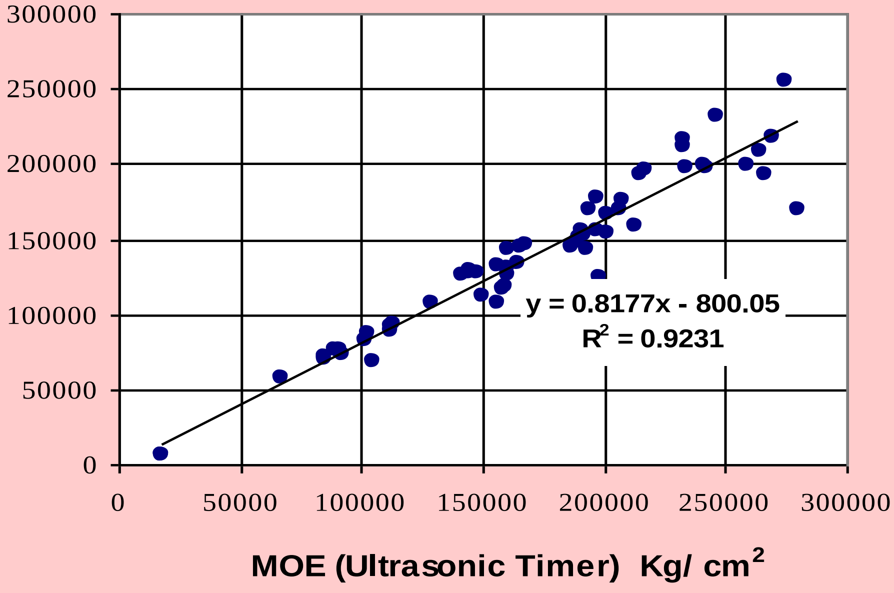


Figure2. Destructive method MOE (Static bending test) vs. Longitudinal MOE (Ultrasonic Timer)

•Relationships between destructive and non-destructive elasticity modulus

The static bending MOE present a correlation coefficient of 0.9602 with the transverse vibration MOE. This means that these two variables are highly related. Moreover, the equation that relates these two variables has a slope close to one, and a minimum value of the independent term, which indicates that this non-destructive technique can be used successfully to estimate MOE in static bending. Fig 3

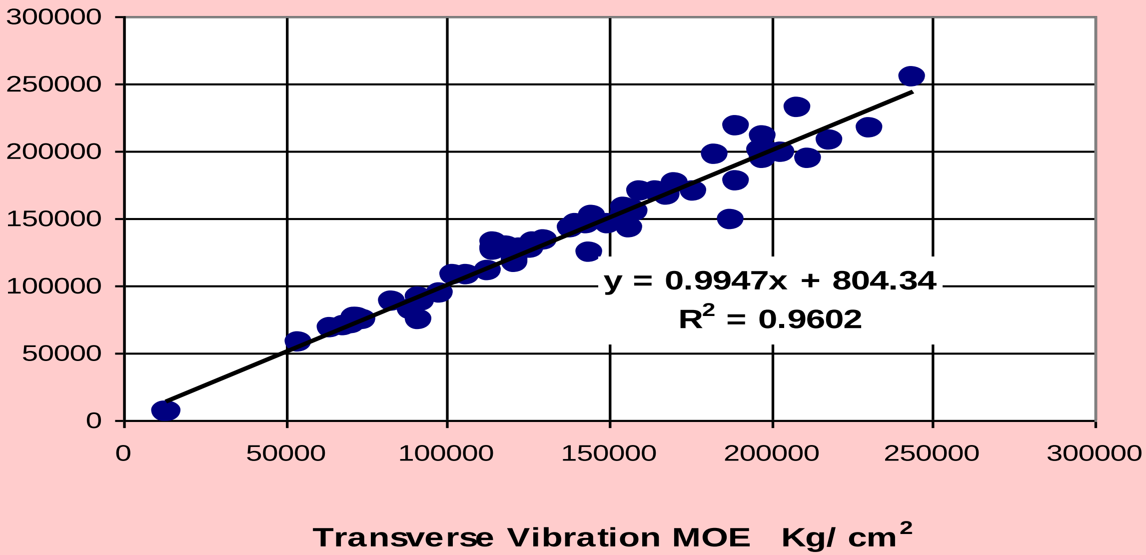


Figure 3. Static Bending MOE vs. Transverse vibration method MOE

•Relationships between destructive (MOR) and non-destructive elasticity modulus

Figures 4. Correspond to the relationships between the MOR and the MOE calculated with the Microsecond timer equipment and it has almost the same characteristic when using the Ultrasonic timer getting with a 0.8259 correlation.

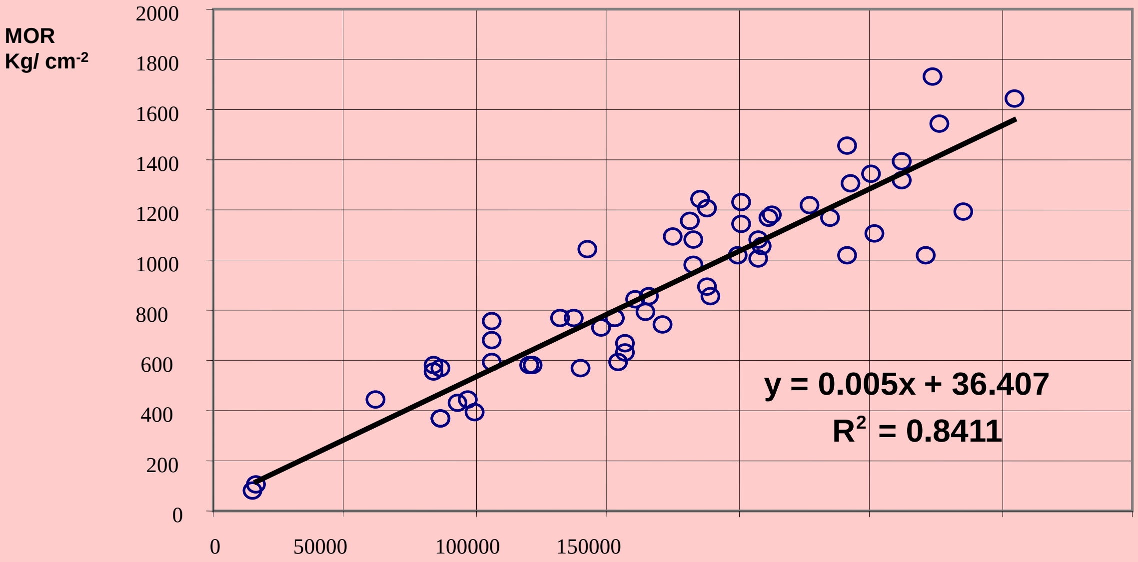


Figure 4. MOR (Static Bending) vs. MOE (Microsecond Timer)

CONCLUSSIONS

- The Static bending elasticity modulus and the Non-destructive methods presented high and positive correlation coefficients.

- Transverse Vibration is the most effective method in determining the bending modulus of elasticity for wood of different densities.

- There was found high linear correlation coefficients between the modulus of rupture determined by destructive method and the modulus of elasticity by non-destructive methods,

- Non-destructive methods used in this study were effective in estimating the elastic modulus in wood of different densities.

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