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Original Research Paper

Physics

STUDY OF ELASTIC PROPERTIES OF DIFFERENT TYPES OF WOOD USING OPTICAL INTERFEROMETER

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ABSTRACT Comprehensive data sets of elastic constants have not been widely studied in Indian wood species. The objective of the present study is to provide information about elastic properties such as Young's Modulus, Rigidity Modulus, Bulk modulus and Poisson's Ratio of certain Indian wood species. These properties have been studied using Optical Interference Method, and the results have been verified using the conventional method of Uniform Bending. Though these techniques have been based on different principles, they yield data on elastic constants which is fairly in good agreement. Optical Interference Method is found to be superior as it gives maximum information regarding the elastic nature of materials.

KEYWORDS :

Introduction:
A survey of literature on mechanical properties of biological materials reveals that enough investigation has not been done on different types of wood found commonly in India.

Wood is a material of biological origin and its complexity arises due to its anisotropic properties. It is orthotropic, i.e, it has unique and independent properties in the direction of 3 mutually perpendicular axes. Wood is hygroscopic, its moisture content has an important influence on wood properties and performance. Information on elastic parameters of Indian wood species is lacking due to the complex nature of the material and experimental effort required for the determination of different parameters.

Nonetheless, experimental work investigating the elastic behavior has been carried out by numerous researchers.

Since 1920, many theoretical investigations on anisotropic elasticity of wood were
published by Jenkin (1920),
Carrington (1923), Price (1928),
Stamer and Sieglerschmidt(1933),
Keylworth(1951), Keunecke,et al (2008),
Niezm and Caduff(2008).

The present study is an attempt to expand the knowledge of elastic properties of Indian wood species using simple laboratory techniques.

Criteria for selection of plants for conversion of wood
A wood material life cycle can be organized into three phases .Pre building, building and post building These stages are parallel to the life cycle phases of building

1.These materials are selected on the basis of nontoxicity and sustainability.

2.Maintenance consumes significant portion of a building operation budget. Over a buliding lifetime, less frequent cleaning is observed of these materials.

3.The materials selected are highly biodegradable.

4.These materials selected are vulnerable to diseases and insects.

Materials and Methods
The wood samples under investigation were collected from the following trees which were locally grown in Kerala. These tropical trees included, ornamental, furniture making and fruit bearing trees . These were chosen based on their local availability, durability, cost and environment friendliness.

	Name of the Tree	Scientific Name	Picture	Area of Origin	Density gm/cm^3
1	Jackfruit tree	Artocarpus heterophyllus		South West India, Bangladesh, Philippines Srilanka	0.6371
2	Guava tree	Psidium guajava		Tropical America.	0.7163
3	Mango tree	Mangifera Indica		Southern Asia	0.6636
4	Teak	Tectona		South East Asia	0.8463
5	Mahogany tree	*Swietenia Mahagoni*		Amazon basin, Parts of Central America.	0.4641

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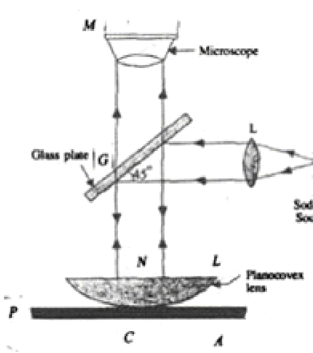
6	**Rosewood**	Dalbergia latifolia		Around Himalayas	0.8364
7	**Wild Jack (Anjili tree)**	Artocarpus hirsute		South West India	0.5313
8	**Silk Cotton tree**	Ceiba pentandra		Asian tropics	0.5072
9	**Cinchona**	Magnoliophyta		Amazonian area of tropics	0.7678

Preparation of wood samples

The wood samples were cut into rectangular bars of suitable dimensions. The surfaces and edges were smoothened for perfection in dimensions. The density of the samples were determined.

Elastic constants of wood by optical interference method

Fig 2.1. Ray diagram of Newton's rings set up



In order to obtain a well defined interference pattern, the surface of the wooden bar should be a good reflector. To achieve this, a small and very thin glass plate (cover slip) was pasted at the centre of the wooden bar, where the light was made to be incident. The wooden sample was placed symmetrically on two knife edges 7.3 cms apart. The sample was then loaded gradually at a distance 'a' from each knife edge.

A parallel beam of monochromatic light was made to fall on a convex lens and the interference pattern was observed with the help of a microscope suitably mounted above the sample. The diameter of the rings was measured in the directions, both longitudinal and transverse to the axis of the sample by means of the microscope capable of moving in these directions in a horizontal plane. The optical interference pattern for two different loads (zero, 450 gm)were studied. Plots were drawn with the number of the ring (n) as abscissa and square of the radius of the ring (r2) as the ordinate for different loads.

The Young's modulus was calculated by using the relation

G_2-G_1=2EIλ(cotψ2–cotψ1) (1)

where E is the Young's modulus and I the moment of area of the cross section of the wood. The couple G that acts on each half of the sample is obtained as G=Mga, where M is the load applied at a distance 'a' from the knife-edge and g is the acceleration due to gravity. G_1 and G_2 in the expression are the couples acting on the sample for loads M1 and M2 respectively. λ is the wave length of sodium vapour light (5893 A°). Cot ψ1 and Cot ψ2 are the reciprocals of the slopes of plots drawn between n and r2 for loads M_1 and M_2 respectively, when the radii are measured in longitudinal direction.

The Poisson's ratio (σ) , the fractional lateral contraction per unit fractional longitudinal extension, was calculated using the relation

$$\sigma=(\cot\psi_1{}^1-\cot\psi_2{}^1)/(\cot\psi_2-\cot\psi_1) \quad (2)$$

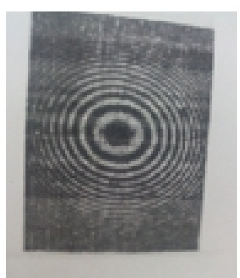
where $\cot\psi_1{}^1$ and $\cot\psi_2{}^1$ are the reciprocals of the plots drawn between n and r^2 for loads M_1 and M_2, when the radii of the rings were measured in the transverse direction.

With a knowledge of Young's modulus (E) and Poisson's ratio (σ), the rigidity modulus (n) and the bulk modulus (K) were computed as

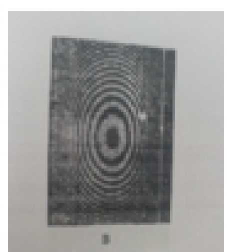
n=E/2*(1+σ) (3)

K= E/3(1-2 σ) (4)

Optical Interferance Fringe Patterns



(a) Zero Load



(b) 450 gm Load

Data on Elastic constants of different types of wood using Optical Interference Method

S No	Wood species	E $*10^{11}$dyne/cm^2	n $*10^{11}$dyne/cm^2	K $*10^{11}$dyne/cm^2	σ
1	Mahogany	1.293	0.5043	0.9885	0.282
2	Teakwood	1.1542	0.4596	0.7874	0.2557
3	Plywood	0.555	0.2145	0.449	0.294
4	Silk cotton tree	0.7719	0.273	1.4925	0.4138

5	Jackfruit tree	1.189	0.4504	1.1009	0.32
6	Mango tree	1.303	0.5191	0.8864	0.255
7	Guava tree	1.403	0.5359	1.2243	0.309
8	Rosewood	1.502	0.6295	0.8154	0.193
9	Wild jack	1.075	0.4005	1.134	0.342
10	Cinchona	1.676	0.6709	1.113	0.249

Comparison of E by different methods			
s no	**wood**	**E*10^{11} dyne/cm^2 by uniform bending**	**E*10^{11} dyne/cm2 by optical interferometer**
1	**Mahogany**	**1.387**	**1.293**
2	Teakwood	1.244	1.1542
3	Plywood	0.432	0.555
4	Silk cotton tree	0.8055	0.7719
5	Jackfruit tree	1.2299	1.189
6	Mango tree	1.3858	1.303
7	Guava tree	1.508	1.403
8	Rosewood	1.5732	1.502
9	Wild jack	1.1449	1.075
10	Cinchona	1.7157	1.676

Conclusion:

- In this study, the basic laboratory techniques such as optical interference and uniform bending were used to evaluate the elastic constants of the wood samples. Though these techniques are based on different principles, they yield the data on elastic constants which is fairly in good agreement.

- Optical interference method is found to be superior, as it gives the maximum information regarding the elastic nature of the materials at a stretch.

- In the absence of sophisticated instrumentation, the above mentioned basic techniques serve as potential tools to determine the elastic constants of materials like wood.

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