Research Paper Engineering

Test of Bamboo Material for Structural Purpose

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ABSTRACT

Bamboo is one of the oldest building materials used by mankind. In Asia, bamboo is quite common for bridges, scaffolding, housing and other Temporary Structure. In many overly populated regions of the tropics, certain bamboos supply the one suitable material that is sufficiently cheap and plentiful to meet the extensive need for economical housing. This paper consist the Physical and Mechanical Properties Tests of Charotar Bamboo (Kheda Region) for its use in structural purpose in Construction Industries and Structural Design Area. All Tests are conducted as per Codal Provision for it. Physical Properties covers the Moisture Content, Density and Shrinkage Test and Mechanical Properties covers the Static Banding Test, Compressive Strength Parallel to Grain and Tensile Strength Parallel to Grain. The material (Bamboo) used for this Tests are felled before six month and neat, clean and free from any defects.

Keywords : Bamboo, Culm, Scaffolding, Physical & Mechanical Properties, Grain.

Introduction

Bamboo is a natural perennial grass-like composite and contains ligno-cellulosic-based natural fibers. Generally it occurs in the natural vegetation of many parts of tropical, subtropical and mild temperature regions, with about 1250 species identified throughout the world. It reaches its full growth in just a few months and reaches its maximum mechanical resistance in just few years. Its height ranges from 10 cm to even 40 m in height. Bamboo plays an essential role in the daily life of millions of peoples. It is seen that everyday about 2.5 billion people in Asia use bamboo for their everyday work. In Bangladesh, a South-eastern country, bamboo is a common material to build low cost houses especially in rural areas. Construction industry is one of the most polluting industries in the world. Production of both concrete and steel causes considerable deterioration of the environment.

Due to high cost of building materials for low cost housing search of low cost housing material is always a good area of research. Wood based building materials such as bamboo are the oldest form of building materials. Research and developments are also made for the effective utilization of natural fibers from coconut husk, sisal, sugarcane bagasse, bamboo, jute, wood, for making concrete.

In some parts of the world many buildings are constructed only with concrete or mud-bricks. This is dangerous in case of seismic activity. These buildings have little hope of standing in the case of an earthquake. Steel reinforcement would be an ideal solution, but cost is a considerable problem. Scientists and engineers are constantly seeking for new materials for structural systems; the idea of using bamboo as possible reinforcement has gained popularity. The tensile strength of bamboo is relatively high and can reach up to 370 MPa. This makes bamboo an attractive alternative to steel in tensile loading applications. This is due to the fact that the ratio of tensile strength to specific weight of bamboo is six times greater than that of steel.

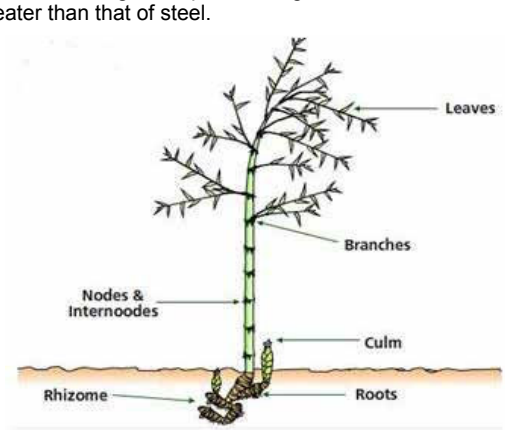


Fig. (a) Structure of Bamboo Plant

This paper consists of Physical and Mechanical Properties Test of Charotar Bamboo (Kheda Region) for its use in structural purpose of Construction Industries and Structural Design Area.

The material (Bamboo) used for this Tests are felled before six month are neat, cleaned and free from any defects. The Physical and Mechanical Properties Tested as per Codal Provisions are as follows.

PHYSICAL PROPERTIES

a) Moisture Content
b) Basic Mass per Volume Density
c) Shrinkage

MECHANICAL PROPERTIES
a) Static Bending Strength
b) Compressive Strength Parallel to Grain
c) Tensile Strength Parallel to Grain

1. PHYSICAL PROPERTIES
1.1 Moisture Content

Procedure
The specimens for determining moisture content are generally be taken from the tested specimens for mechanical testing, immediately after completion of each test and, as far as possible, from near the place of failure. It shall be about 25 mm in length and 25 mm in width and having full wall thickness.

Specimen is weighted before and after the oven dry and moisture content to be obtained.

Calculation
The moisture content of each test specimen is calculated as the loss in mass, expressed as a percentage of the oven dry mass.

Moisture content percent = $\frac{m_i - m_0}{m_0}$ x 100

Where m_i = initial mass of the test specimen, in g; and

m_0 = oven dry mass, in g.

Experiment Result
Sample (1) = 9.31 %

Sample (2) = 9.15 %

Average Moisture Content = 9.20 %

1.2 Basic Mass per Volume or Density

Procedure
The test specimen for determining basic mass per volume is taken from freshly felled culms at different positions of the Culm (base, middle and top). It is about 25 mm in length and 25 mm in width with full wall thickness.

The volume shall be measured by water displacement method. Considering the specific gravity of water as 1.0, this reading shall be considered as the volume of the test specimen, in cm3 (Vg).

Calculation
Mass per volume, in kg/m^3 = $\frac{m_0}{V_g}$ × 100

Where

m_0 = oven dry mass, in g; and

Vg = green volume, in cm^3.

Experiment Result:- m_0 = 3.306 g

Vg = 3.125 cc

Mass per volume, in kg/m^3 = m_0/vg x 100

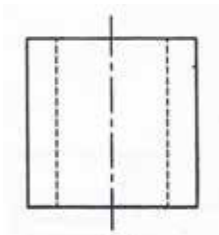
= 1058 kg/m3

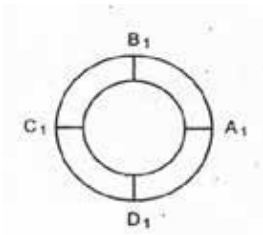
1.3 Shrinkage

Procedure
The test specimens are taken from freshly felled culms, preferably from the lowest section of the Culm. Specimens are to be 100 mm in length and free from nodes.

Shrinkage is determined along diameter, wall thickness and length of the test specimen. Length and diameter is measured correct to 1 mm while the wall thickness shall be correct to 0.1 mm.

Then specimen is placed in a hot-air over at 103 ± 2°C till it reaches a constant weight. The mass and dimensions of the specimens is taken at the oven dry condition.





Calculation
Shrinkage percentage (along diameter or wall thickness or length) correct to one decimal place is calculated as follows:

Shrinkage along diameter,

$$\text{Percent} = \frac{D_i - D_f}{D_i} \times 100$$

Shrinkage along wall thickness,

$$\text{Percent} = \frac{t_i - t_f}{t_i} \times 100$$

Shrinkage along length,

$$\text{Percent} = \frac{l_i - l_f}{l_i} \times 100$$

Where

D_i,t_i,l_i= initial dimensions of outer diameter, wall thickness and length, respectively, in mm; and

D_f,t_f,l_f = final dimensions of outer diameter, wall thickness and length, respectively, in mm.

Fig. (b) Specimen for the Test of Shrinkage

Experiment Result
Shrinkage along Diameter = 0.384 %

Shrinkage along Wall thickness = 1.50 %

Shrinkage along Length = -1.35 %

2. Mechanical Properties of Bamboo
2.1 Static Bending Strength

Procedure
The test specimens, free from defects like cracks and crookedness, are taken from the air-dried and conditioned culms. The test specimens are also free from wide varying taper. The length of the specimens is at least 30 times diameter at the middle point plus 1m.

As shown in Fig.(c), the test specimen is placed on supports with saddles and a wooden beam is placed over the specimen using saddles in such a way that load is applied through the loading head of the testing machine.

The loading of the test specimen is carried out uniformly at constant speed. The loading head of testing machine is move

at the rate of 0.5 mm/s. Deflection at the middle of the span is noted by means of a dial gauge.

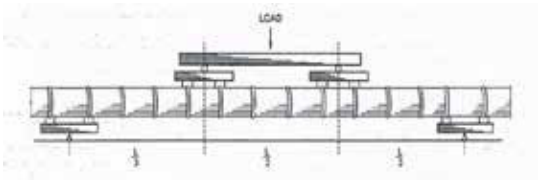


Fig.(c) Method of Applying Load and Supporting Bamboo with Saddles

Calculation

a) The moment of inertia I in mm4 shall be calculated as follows:

$$I = \frac{\pi}{64}[D^4 - (D - 2t)^4]$$

Where

D = outer diameter, in mm; and

t = wall thickness, in mm.

b) The ultimate strength σult in static bending, in N/mm2, shall be determined as follows:

$$\sigma ult = \left[\frac{1}{6\,I}\,(FL\ \frac{D}{2})\right]$$

Where

I = moment of inertia, in mm4
F = maximum load, in N;
L = effective span, in mm.

c) The modulus of elasticity (Young's modulus), E, in N/mm2, shall be determined as follows:

$$E = \frac{23\,s\,L^3}{1296\,I}$$

Where

L = clear span, in mm;

I = moment of inertia, in mm^4; and

s = slope of a linear part in the load deflection diagram, in N/mm2.

Fig. (d) Static Bending Test on UTM

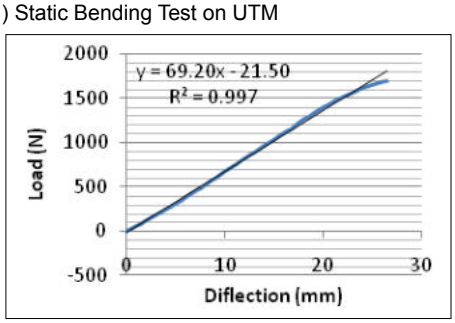


Fig. (e) Load vs Deflection Curve for Sample

Experimental Result:

2.2 Compressive Strength Parallel to Grain

Procedure

Specimens for compressive strength tests are taken from the undamaged ends of specimens used in static bending tests. The test specimens are from internodes. The length of the specimen is taken equal to the outer diameter. Outer diameter and wall thickness is measured as described in Shrinkage Test. the end planes of the specimen are perfectly at right angles to the length of the specimen; the end planes are also flat, with a maximum deviation of 0.2 mm.

The load is applied continuously and the movable head of the testing machine shall travel at a constant rate of 0.01 mm/s. The maximum load at which the specimen fails is being recorded.

Calculation

The maximum compressive strength σult N/mm^2, shall be determined as follows:

$$\sigma ult = \frac{F_{ult}}{A}$$

Where

Fult = maximum load, in N;

A = area of cross-section of test specimen, $\frac{\pi}{4}[D^2 - (D - 2t)^2]$

, in mm2;

D = outer diameter, in mm; and

t = wall thickness, in mm.

Experimental Result

	Sample- 1	Sample- 2
Moment of Inertia (I)	66204.789 mm4	68094.032 mm^4
The Ultimate Strength ($_{\sigma ult}$)	177.42 N/mm^2	93.91 N/mm^2
Modulus of Elasticity (E)	3.2 × 10^4 N/mm^2	2.85 × 10^4 N/mm^2

Fig. (f) Specimen for the Compression test

Experiment Results:

Sample (1) $_{\sigma ult}$ = 107.5 N/mm^2

Sample (2) $_{\sigma ult}$ = 111.5 N/mm^2

Fig. (g) Compression Test

2.3 Tensile Strength Parallel to Grain

Procedure
The grips of the testing machine is ensure that the load is applied along the longitudinal axis of the test piece, and is also prevent longitudinal twisting of the test piece.

The grip is press the test specimen perpendicular to the fibers and in radial direction. The load is applied continuously and the movable head of the testing machine shall travel at a constant rate of 0.01 mm/s. The maximum is record.

Calculation
The maximum tensile strength σult N/mm^2, shall be determined as follows:

$$\sigma ult = \frac{F_{ult}}{A}$$

Where

F_{ult} = maximum load, in N;

A = area of cross-section of test specimen, in mm2.

σult shall be rounded to the nearest full number.

Experimental Result

Sample	(1)	(2)	(3)	(4)
Area (mm^2)	88.56	81.4	67.5	55.8
Fult (N)	9800	9750	7250	5700
σult (N/mm^2)	110.66	119.77	107.40	102.15

Avg. Tensile Strength = 109.98 N/mm2.

Fig. (h) Tested Specimen

IV. CONCLUSION:-
From above experiments it can be observed that the relative properties of Bamboo are far better than other wooden material as strengthening point of view. The properties of Charotar region Bamboo are as, Moisture content 9.20%, Density 1058 kg/m3and Shrinkage along Diameter, wall thickness and Length as 0.384%, 1.50%and -1.35% respectively. Static Bending Strength content the ultimate Strength (σult) and Modulus of Elasticity (E) are 135.67 N/mm2 and 3.02×104 N/mm2.

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