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ASSESSMENT OF MECHANICAL PROPERTIES OF BAMBOO AND ITS COMPATIBILTY AS TRUSS MEMBER

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Abstract - This paper presents the experimental verification of bamboo for taking axial loads and further using structural analysis and design concepts to utilise its strength for design of modern engineered structures . A detailed truss is presented with bolted connections. Other members like sway bracing, stringers etc. were also bamboo based. For the designed loads as prescribed by Indian Standards not only the structure is lightweight but also cost effective. This paper presents the possible minimization of steel, production of every ton of which emits several tons of gases in the atmosphere, by bamboo as a modern engineering construction material. Also, growth of every ton of bamboo consumes nearly a ton of CO_2 besides releasing fresh O_2 into the atmosphere.

***Key Words*: Bamboo, Truss, Bridge, Eco-friendly**

1. INTRODUCTION

2. METHODOLOGY

A) MATERIAL TESTING

As per IS 6784-2008
Test-01 To determine Specific Gravity of bamboo sample
Test-02 To determine Moisture content present in bamboo sample
Test-03 To determine Compressive strength of bamboo sample
Test-04 To determine Flexure strength of bamboo sample
Test-05 To determine Elastic Modulus of bamboo sample
Test-06 To determine Tearing strength of bamboo sample

Determination of Specific Gravity

The test specimens for determining basic mass per volume shall be taken from freshly felled culms at different positions of the culm (base, middle and top). It shall be about 25 mm in length and 25 mm in width with full wall thickness. This test will also enable determination of the moisture content of the green specimen. As per IS 6784-2008 Specific gravity

$$\text{Mass per volume, in kg/m}^3 = \frac{m_o}{V_g} \times 100$$

where

m_o = oven dry mass, in g; and
V_g = green volume, in cm^3.

Fig.1 Specific gravity Sample

Determination of Moisture content

The specimens for determining moisture content shall be taken at least 150 mm away from the nearest edge of the culm. The test specimens shall immediately be put in a polythene bag in order to ensure no loss of moisture. The test specimens shall be weighed to an accuracy of 0.01 g and then dried in a hot-air oven at a temperature of 103 k 2°C for 24 h. The test specimen shall then be weighed and drying continued thereafter. The final mass shall be considered as the oven dry mass

$$\text{Moisture content, percent} = \frac{m_i - m_o}{m_o} \times 100$$

where

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

m_o = oven dry mass, in g.

Determination of Compressive strength

As per IS 6874-2008, Specimen for compressive strength was taken from undamaged ends of specimen used in static bending test. The maximum load at which the specimen failed wasrecorded. Compressive strength calculated as:

where

F_{ult} = maximum load, in N;

A = area of cross-section of test specimen

$\frac{\pi}{4}\left[D^2 - (D-2t)^2\right]$, in mm²;

D = outer diameter, in mm; and

t = wall thickness, in mm.

σ_{ult} shall be rounded to the nearest 0.5 N/mm².

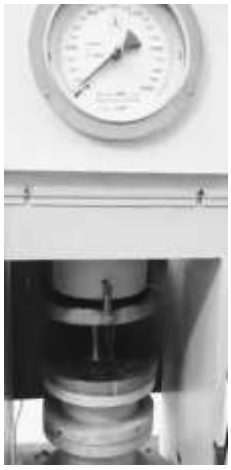

Fig.2 Compression test of bamboo

Determination of Flexure Strength

The test specimens, free from defects like cracks and crookedness, shall be taken from the air-dried and conditioned culms. The test specimens shall be free from wide varying taper Load at which bamboo specimen fails is 4.0kN

Fig.3 Flexure test of bamboo

Determination of Elastic Modulus

Elastic modulus of bamboo was determined as per IS 6874-2008 as, Static Bending test was performed to determine elastic modulus. For this the test specimens, free from defects like cracks and crookedness, shall be taken from the air-dried and conditioned culms. The test specimens shall be free from wide varying taper. The length of the specimens shall be at least 30 times diameter at the middle point plus 1 m.

$$E = \frac{23\,s\,L^3}{1\,296\,I}$$

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/mm.

E shall be reported by rounding to the nearest 100 N/mm^2.

Determination of tearing Strength

Specimens for tensile strength test shall be taken from the undamaged ends of specimens used in static bending tests. The test specimens shall be with one node in the center. The general direction of the fibers shall be parallel to the longitudinal axis of the test specimen.

Fig.4 Tearing Strength of bamboo

Table.1 Test Results

Property	Result
Specific Gravity	10.75
Moisture Content	6.67%

Compressive Strength	65N/m^2
Tearing Strength	16455.7kN/m^2
Elastic Modulus	437000kN/m^2

DESIGN PHILOSOPHY

FORCE ANALYSIS

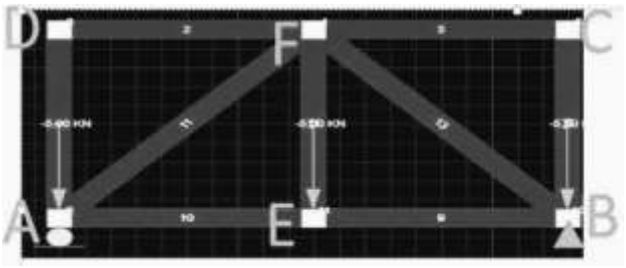

Fig. 5 Truss schematic

Table2 Test results

Member	Force(kN)
AD, DF, FC,CB	0
FB, AF	10.5
EB	-7.5
FE	5

DESIGN PHILOSOPHY

- As per derived result from calculations it was concluded that depth to span ratio of truss should lie between 1/3rd to 1/10th depending on many other factors, major is economy.
- Inclination of members should vary between 30^0 to 60^0, best result is for 45^0.
- Zero force members are employed to provide Stability, restraint against wind loads and safety in case of failure of any individual member. For moving loads zero member forces may transfer forces.

Software Analysis

To effectively study the structural behavior of bamboo as structural member, it is crucial to study how a bamboo responds to various loading conditions. To achieve this a plan of Truss using Staad Pro was used Key points of analysis:

a. Modeling and loads
b. Material properties
c. Deflection

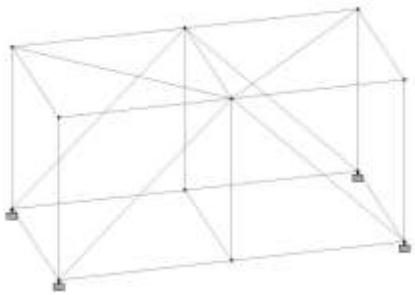

Fig.6 Modelling of truss

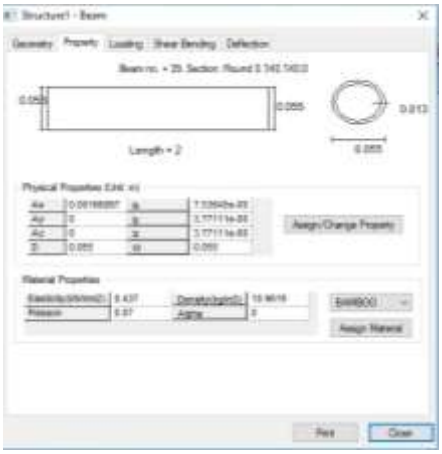

Fig.7 Material properties

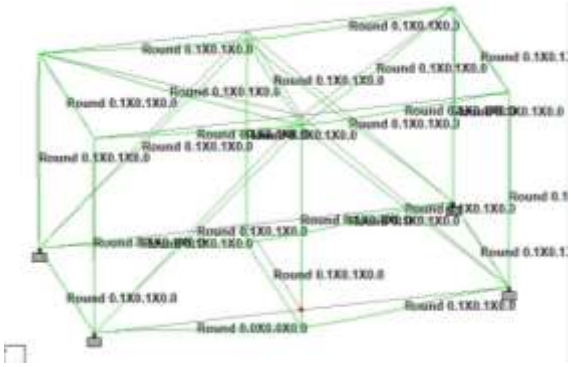

Fig.8 Deflection of members

FABRICATION AND TEST FOR SERVICIABILITY

Fabrication of truss brought itself many unaccounted challenges. This backbreaking task require skilled workmanship and proper planning of resources to maximize utilization.

Bamboo cutting and adjustments were performed at Carpentry workshop and Gusset plate of provided sizes were drilled at Metal workshop.

Fig. 9 fabricated bamboo truss

RESULT

From the above analysis it can be concluded that for low traffic conditions bamboo trusses are serviceability acceptable. Maximum deflection in software analysis was 13mm.

Load applied at mid	Deflection observed at mid
64 kg	2.5mm
79kg	2.8mm
87kg	3.25mm
143kg	4.1mm
162kg	4.5
175kg	4.9mm
190kg	5.1mm
195kg	5.2mm

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