

# MATERIAL STRENGTH EVALUATION OF PIPTADENISTRUM AFRICANUM FOR STRUCTURAL DESIGN

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## Abstract

Deforestation has necessitated search and evaluation of other lesser known timber material to meet the increasing demand of bio-material for its utilization in the construction industry; the present studies focuses on physio-mechanical properties of Piptadenistrum africanum wood species for its use in civil construction. Material properties were evaluated based on two reference moisture content of 20% -12%. 20% (above the fibre Saturation point) 12% (equilibrium moisture point); results obtained were statistically analysed according to the t-test at the 5% level of significance. The physical and mechanical properties from the study indicate favourable properties with known timber material (Gmelina); for construction of timber structure as structural members.

**Keywords:** Stiffness, Axial loading, Moisture content, Stiffness, Strength, Sustainability, Timber construction, Piptadenistrum africanum,

# 1. INTRODUCTION

The unique characteristics and comparative abundance of wood have made it a natural material for various end uses, such as furniture, tools, Floor, wall panelling and other structural purpose etc. In-depth knowledge of properties of material and its availability enhances its utilization in any engineering application, Wood is one of the renewable materials used for building purposes due to favourable characteristics; like workability, and high strength to weight ratio. As a global raw material for construction, along other basic construction material, such as cement, plastic, steel, etc. The rapid growing world demand for various end uses and its complex internal multicomponent structure (anisotropy nature of the material); these variations influence the suitability of wood, viz wood quality for variety of purposes. The utilization of wood materials shows an upward demand in the building and construction due to some requirements of modern societies being an environmentally friendly and a sustainable material. However, end users of wood materials are frequently confused about these wide variation of wood properties, inline, manufacturer need this in-depth knowledge of wood properties and potential of wood for various products [8][12][13][15]. In Nigeria, dearth of information of strength properties of wood material have imposed, high demand on some species of known material properties resulting to higher depletion of those species in the forest. For Timber construction the knowledge of Physio- mechanical properties of wood are very important, for its end uses [10][1]. The aim of characterization of material is to evaluate its possible use as a structural member [15][6]. *Piptadeniastrum africanum* is a species that is originated from Nigeria, due to dearth of information of this renewable material is generally used for local medication with less scientific based. Literature shows, *P. africanum*, the species is widely known in Uganda for construction purposes, yet to be recognized in my locality for loading bearing construction. In Europe the wood is considered an excellent replacement for oak (*Quercus* spp), the vast biomaterial is not widely accepted in the study area for load bearing construction, despite its availability. The moisture content of wood material influenced dimensional stability and increase in mechanical properties, weight ratio to strength [10][15][11]. Massive utilization of timber material for loading bearing and other moderate load bearing construction is trending, that is returning to nature, increasing its demand for consumption. The strength properties of wood material due to its anisotropic nature depend on the density, moisture content, extractive

materials such as (resin, rosin etc) among other factors. [3] The availability of the species is a determinant of its strength appraiser, the study was aimed at determining the physio-mechanical properties; at two moisture content regimes 12% and 20% for its maxi-utilization of the biomaterial for structural purposes.

## Materials and methods

*Piptadeniastrum africanum* wood from a saw mill, the age of the wood 15 years was determined by the growth ring, with an average 30cm diameter were selected for the study. The log was given primary processing, the

$n - 1$

sawn timber of *P. africanum* were air dried and further oven dried under a control temperature of 150°C to the required moisture content adopted in the study; first above the fibre saturation point (FSP) 20% and 12% moisture content according to ASTM D143-94.

The test samples were machined according to their ASTM standards for various physical and mechanical properties. Test samples studied, moisture content was determined for 12% and 20% respectively, except for apparent density which is basically determined at 12

%M.C. for impact test were carried out in Charpy impact machine in accordance to ASTM D 143, other tests were conducted using Universal Testing Machine (UTM); with a loading capacity of 10kN with cross head of 0.01mm/s. Table 1 shows list of physio- mechanical properties examined.

Table 1: Physio-mechanical properties study.

S/N	Properties	Symbol
1	Apparent Density	$\rho_{ap}$
2	Density	$\rho$
3	Compressive parallel to grain	$f_{\parallel \text{grain}}$
4	Compressive perpendicular to grain	$F_{\perp \text{grain}}$
5	Tension parallel to grain	$F_{t0}$
6	Tension perpendicular to grain	$F_{t90}$
7	Modulus of rupture in static bending	$f_M$
8	Modulus of elasticity in compressive parallel to grain	$E_{c0}$
9	Modulus of elasticity in compressive perpendicular to grain	$E_{c90}$
10	Modulus of elasticity in tension parallel to the grain	$E_{t0}$
11	Modulus of elasticity in static	$E_M$

bending

12	Parallel hardness	FH0
13	Perpendicular hardness	fH90
14	Toughness	W

Results from fourteen physio- mechanical properties tested, exception apparent Density. Basically determined at 12% moisture content; were study and analyzed through t-test at a significance level of 5%(P- value  $\leq 0.05$ ), investigation of moisture content influence it material properties. Strength properties from the study were determined with Equation 1. Strength properties of 8 test specimens, were placed in ascending order for evaluation of the characteristic strength of *P. africanum* wood.

$$= \frac{f_1 + f_2 + \dots + f_n}{n} \quad (1)$$

#### Result and discussion

The basic density of *P. africanum* decreased from 20% to 12 % to 1.65%. (0.46g/cm<sup>3</sup>) Through the t-test. density  $\rho$  not suffered the influence by the variation in moisture contest. Table 2, shows density of *P. africanum* from the studies. The density of wood studied in this research at 12% moisture content shows lower MC% than 0.61g/cm<sup>3</sup> and 0.52g/cm<sup>3</sup> as reported by [7] [2] [14]. Average density compares favourably with Nigerian wood species [4].

Table 2: Density of *P. africanum*

Properties	MC(%)	n	X	Sd	P- value
Density(g/cm <sup>3</sup> )	12	76	0.73	0.16	-----
	20	72	0.58	0.16	
					0.6660
	12	76	0.57	0.13	

Table 3. Strength properties of *P. Africanum*

Properties	MC(%)	n	x	Sd	P- value
Comp. parallel to grain	20	73	37.60	7.60	0.0001
	12	70	45.78	14.31	
Comp. perpendicular to grain	20	73	4.59	2.10	0.5720
	12	74	4.70	2.19	
Tension parallel to grain	20	73	74.50	33.30	0.0015
	12	73	95.40	44.30	
Tension perpendicular to grain	20	76	3.20	1.20	0.0000
	12	76	3.90	1.70	
Modulus of rupture in static	20	73	73.10	14.00	0.0003
	12	73	90.60	37.20	

The strength of wood material shows increases in strength with decreases in moisture content of the wood in the study, compressive strength parallel to the grain is 9.3N/mm<sup>2</sup>, compressive strength perpendicular to the grain is 4.27N/mm<sup>2</sup> and the tension strength parallel to grain was 24.35% of 2.2N, tension perpendicular to the grain 17.9N, the static bending which showcase the modulus of rupture of the material is 7.8N/mm<sup>2</sup>. Decrease in Moisture content (20-12%) has influence on the properties of compressive parallel/ perpendicular to the grain and tension parallel/ perpendicular to the grain as showed by the t-test analysis (P-value  $\leq 0.005$ ); the analysis is similar to the results recorded by [15] [4] [1]. The influence with moisture content was not similar in modulus of rupture in static bending, this shows not significant difference in their mean with respect to moisture content.

Table 4 Stiffness of properties

Properties	MC(%)	n	x	Sd	P- value
Modulus of Elasticity comp. //grain	20	75	13.076	4,021	
	12	72	15,261	4,342	0.0022
Modulus of Elasticity comp. 1 grain	20	73	456	211	
	12	72	467	216	0.5454

Modulus of elasticity in tension //grain	of20	75	12,542	3,675	
	in12	75	14,874	4,856	0.0017
Modulus of Elasticity in static bending	of20	73	12,207	2,540	
	in12	74	13,413	3,753	0.0665

The stiffness properties of the material take into account the behaviours of material in responses to forces that tend to pull the fibre orientation of the wood. From the study, it was observed that, modulus of elasticity in compressive parallel and perpendicular to grain of wood increases with decrease in moisture content ratio of 20% to 12% respectively, 14.41% (2.185N) in compression parallel to grain, and 3.16% (2.279N); in tension parallel to the grain is 7.56%(1.07N). the t-test analysis has influence on the stiffness properties with decrease in the moisture content, furthermore, the t-test analysis shows that, modulus of elasticity in static bending has great influence in their material properties with decrease in moisture content (P-value  $\leq 0.05$ )

Table 5: Mechanical properties of *P. africanum*

Properties of Material	MC %	n	x	Sd	P- value
Parallel hardness	20	72	5,150	1,320	0.0046
	12	72	6,220	3,150	
Perpendicular hardness	20	74	5,560	1,730	0.0094
	12	72	6,670	3,010	
Toughness	20	76	10.7	4.20	0.0017
	12	74	12.3	5.30	

\_\_\_\_\_ The hardness parallel to the grain of material at 20%

MC (1.32N) tends to have low material property compared to 12% MC (2.34N); these shows that moisture content only has a contributed benefit to bio- material during conversion processes and avert effect on mechanical properties. This is similar, as reported by [15] the perpendicular hardness shows upshot on strength with decrease in moisture content from 20% to 12%, the t- test analysis has influence on the hardness on the bio-material

with respect to moisture content variation. Same strength increase is play out toughness examination the material with considerable upshot strength with decrease in moisture content, 1.3N and 2.65N respectively.

## CONCLUSION

From present study, *P. africanum*, showed basic strength properties that showcase potential of maxi- utilization of material, it shows some similar material properties like *Gmelina* which is widely known in my locality, when seasoned within the reference moisture content examined in the study, is safe as a structural element on timber structures. At 12 to 20% moisture content evaluated mechanical properties presented significant differences. Strength properties showed an improvement in their mechanical properties with decrease trend in moisture content.

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