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An investigation of the breaking strength of timber from different tree species used for school furniture in Walukuba Division, Jinja City, Uganda

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An investigation of the breaking strength of timber from different tree species used for school furniture in Walukuba Division, Jinja City, Uganda

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ABSTRACT

The study investigated about the breaking strength of wood in Walukuba Division Jinja City. In this study we aimed to**:** to determine the breaking strength of different wood types varying length and extension while keeping force and area constant and to determine the breaking strength of different wood types by varying force and length while keeping area and extension constant. In this experiment we studied timber from Eucalyptus, Maesopsis eminii and Markhamia because they are the most common species in the study area.

The cantilever method was used where a known mass was attached to the free end of a wood rod and the extension was noted. The experiment was repeated with various masses from 100 to 600grams. We varied the length of wood and kept noting the extension this time round varying the length of the wooden rod while maintaining a load of 100g and noting the extension on the meter rule that was clamped vertically at the extreme end using a retort stand.

The results showed the young's modulus of elasticity of 1267.27,1164.74, and 709.72Nm^{-2} for Eucalyptus, Musizi and Makhamia timber respectively. With these results we deduce that timber form Eucalyptus could withstand higher load without breaking as compared to others we recommend that Eucalyptus should be used in generation of furniture for institutions moving forward.

Key words: Breaking Strength, Wood, Jinja City.

INTRODUCTION

Despite the efforts by Ministry of Education and sports to supply furniture in government Secondary Schools, there is still a big gap of furniture for students due high breaking rates. Based on the statistics of 2018, 9 billion shillings was spent on development projects in secondary school. This increased to 10.5 billion shillings in the financial year 2018/19. There is need to know the mechanical properties of alternative timber species to supplement and replace the depleted species. Modern research on wood has substantiated that location and growth conditions do significantly affect wood properties[8]. However, currently in Uganda structural timber designers and users rely on documented strength values of timber grown in temperate countries which may result in wastage of wood material because information on mechanical properties of Ugandan timber is inadequate, outdated or non-numeric. The lack of data on characteristic strength properties of alternative Ugandan tropical timber species other than the ones commonly in use has facilitated depletion of valuable species due to limited options. It is important therefore to investigate on the many wood species available in Uganda as a whole and in Jinja in particular to establish their breaking strength and those that can be found to be good enough for construction can be recommended for construction to reduce pressure on the popular species. The study therefore investigated the breaking strength of wood in Walukuba Division Jinja City.

Globally, there is a series of construction materials that can be used in the manufacture of seats in schools among which include: cast iron, steel, titanium, ceramics, natural building stones[1].Other construction materials are polymers, polypropylene and polybutylene plastics, silicon, fibre reinforced polymer composite materials and timber[1]. Wood is often a desirable constructional material even when considering tall structures in residential, industrial, educational and recreational buildings, as well as in infrastructural facilities, owing to be natural, biological, recyclable and renewable[2] . It is used for load-bearing structural members, window frames, furniture, linings, and numerous other products, such as strand boards, cardboards, products in pulp and paper industry[3].

Wood refers to the hard-fibrous material that forms the main substance of the trunk or branches of a tree used for fuel or timber. The main tree species for wood globally include Leguminosae, Rubiaceae, Myrtaceae [4] For Uganda the common and recommended tree species for timber/furniture include; Maesopsis eminii, Vernonia amygdalina and Lasiodiscus mildbraedi [5]**.** *Albizia coriaria*, *Markhamia lutea* and *Chrysophyllum albidum*, *Khaya spp, Milicia excelsa* and *Olea spp* **[6].**

Wood plays different roles including; the manufacture of load bearing structures, window frames, furniture, linings, and numerous other products, such as strand boards, cardboards, products in pulp and paper industry[3]. It is also known to be the most flexible, diverse and long lasting building materials lasting approximately 200Years [7].

As a building material, the demand for quality timber in Uganda is on the rise due to the current boom in the construction industry as reported in the National Population and Housing Census of 2016 by the Uganda Bureau of Statistics, increased population led to increased demand for housing. The forest cover has gone down from 4.9 million hectares in 1990 to 3.6 million hectares in 2015, representing a 27% drop[6]. With the ongoing over-exploitation and scarcity of traditional timber species such as *Milicia excelsa (Muvule), Entandrophragma angolense (Mahogany),* there is a variety of previously unpopular species on the market[7]. The mechanical performance of wood depends on numerous factors, for instance, material properties, mechanical load or deformation modes, and climate conditions with changing temperature and relative humidity of the ambient air. Although, the demand for quality timber as a construction material world over is ever increasing due to a number of reasons, the knowledge gap too is increasing hence its demand for continuous research for better solutions. Heavy wood members typically used in bridges and big construction projects provide a fire resistance comparable to, or greater than, that of steel or aluminum of similar sections[5].

However, some of the challenges faced by professionals and property developers alike include lack of adequate technical data regarding mechanical properties on alternative species that could be utilized in the market. The current popular timber species available on the market are facing the pressure due high demand leading to scarcity and harvesting of immature trees, thus other alternatives that could be available need to be studied to establish their suitability for construction use. Reliable structural use of timber in Uganda has always been hampered by lack of knowledge

about the mechanical properties such as breaking strength of wood. This study is therefore set to investigate the breaking strength of wood on market in Walukuba Division Jinja City. In this study, breaking strength of wood will be defined as ability of a piece of wood to withstand the forces applied to it before collapsing.

The rationale for this project was that the evidence generated from this study would contribute to the knowledge society, this study will not only avail additional knowledge on scientific data of the studied species to those in the timber supply chain like engineers, planners, suppliers among others but will also engender better species matching to use, which will lead to sustainable utilization of timber. Furthermore, The findings of the study will give information on the breaking strength of different types of wood commonly used in Walukuba Division, Jinja city. This information will be used by the people especially the engineers in selecting right wood for the right job in the construction industry. It will thus promote development of the decent housing sector, thereby leading to social transformation which entails access to decent shelter by the population in both rural and urban settings thus achieving the Uganda's vision 2040 of a transformed Ugandan society from a peasant to a modern and prosperous country within 30 years.

Derivation of key equations

(i) The Breaking Strength of Wood

The strength of wood deals entirely with the effect of force and moments on the deformation of a piece of wood, there need to consider the theory of three-dimensional stresses, simples bending theory, theory of failure and mechanical properties which wholly depend on Hooke's law[10].

$F = ke$ ……1.1

In bending failure, cracks occur in the tangential direction at the compression zone, called kink bands, and in the longitudinal direction at the tension region. The longitudinal cracks are caused by the rupture of the fibers, such that a sudden collapse, which will eventually occur due to these failures at the tension region. Therefore, the cross-sectional properties and grain direction of wooden beams are important to the resistance to bending forces. Thus, it is important to evaluate and compare the bending strengths and moduli of elasticity of the softwoods that are utilized in wooden structures[10].

The maximum stress (σ) is determined by Eq. 1

$$\sigma = \frac{M}{Z} \quad \text{……1.2}$$

Where M is the maximum bending moment and Z is the section modulus of the cross- section.

(ii) Tensile strength of wood

Tensile strength is the ability of a material to resist the force that pulls the material and tries to elongate or stretch it[11]. Tensile strength perpendicular to the grain is important in design of the connections between wood members in a building. In contrast, tensile strength parallel to the grain is important for the bottom member in a wood trusses and in the design of connection between structural members[12]. However, because of the excessive variability associated with ultimate stress in tension perpendicular to the grain, design situations that induce this stress should be avoided[13].

(iii) Stress and Strain

Wood can undergo a certain load, or stress, before breaking. Stress is a distributed force per unit area, and occurs when a force or load acts on a solid member, such as a load on a column. Stress is often expressed in units of pounds per square inch (psi) or pascals (Pa or N m-2). When stress is applied to a rigid body like a block of wood, distortion of the wood occurs. A large stress will cause the wood to fail and break[14].

Low stresses will cause the wood to distort (bend or shrink) without actually breaking. The *stress* **the column is subjected to is equal to the force per unit area**, calculated as:

$$stress = \frac{Force}{Area} \quad \text{.....1.3}$$

Strains may be divided into normal strains and shear strains on the basis of the forces that cause the deformation. A normal strain is caused by forces perpendicular to planes or cross-sectional areas of the material, such as in a volume that is under pressure on all sides or in a rod that is pulled or compressed lengthwise[15].

A shear strain is caused by forces that are parallel to, and lie in, planes or cross-sectional areas, such as in a short metal tube that is twisted about its longitudinal axis. The *strain* **is the ratio of the change in length between the stressed and unstressed column**. Therefore, the change in length divided by the original length is called **strain** which is a unit-less measure[16].

(iv) Young's Modulus of Elasticity of Wood

Modulus of Elasticity (MOE) or Young's Modulus is a value that represents how stiff or rigid the wood is[17].

$$\text{Young's modulus} = \frac{stress}{strain} \quad \ldots\ldots 1.4$$

Many research works have investigated the aging effects on the bending Modulus of Elasticity (MOE) or the bending strength (MOR) of old timber, since the MOE is well related to the overall quality of timber and MOR is usually the most important and limiting factor in timber structures. The **maximum bending strength** of wood is expressed in terms of the **Modulus of Rupture (MOR)**. The MOR is calculated from the maximum load — the load that causes the wood to fail AKA breaks[18].

In some cases, the mechanical properties of wood were not being significantly affected by aging process if the wood is preserved by decay phenomena[19]. They reported a significant bending strength reduction. This explains why the effect of aging on the mechanical properties of old timber is still of interest for architects and structural engineers.

Shear modulus (G) is the ratio of shear stress to shear strain, describing the material's response to shear stress. It is a basic property of materials, essential for the efficiency of construction procedures[20] when short members are considered within a structure or for parts subjected to torsion action and when timber is loaded in bending, because in nearly all cases, deflection is also affected by G. It is also used by structural engineers for finite element analysis and for various strengthening intervention designs such as beams ends prosthesis.

Finally, the MOE/G ratio is used in design equations to determine torsional rigidity and to predict structural beams' lateral torsional stability. Shear modulus is usually assumed as a portion of MOE, because in clear wood both are related to the density and the microfibril angle within the cell walls. For structural timber, G is also affected by many other features such as slope of grain, knots and presence of pith[21].

Measurement of Mechanical Properties of Wood

Standard test methods are available to determine the mechanical properties of timber. These tests are normally performed on timber that has been conditioned to about 12% moisture content. The

size of the specimens and the rate of loading are prescribed. Testing is usually performed to the standard[22].

Bending properties are normally determined by symmetrically loading a specimen at the third points of a simply supported span of 18 times the specimen depth. This method is referred to as a 'four-point' bending test and the intent is to create a zone of constant moment with no shear in the most highly stressed mid third of the beam under test. The modulus of elasticity is determined from the slope of the load-mid span deflection curve and the bending strength is determined from the maximum load and the section modulus. This same test setup may also be used to determine the shear modulus[23].

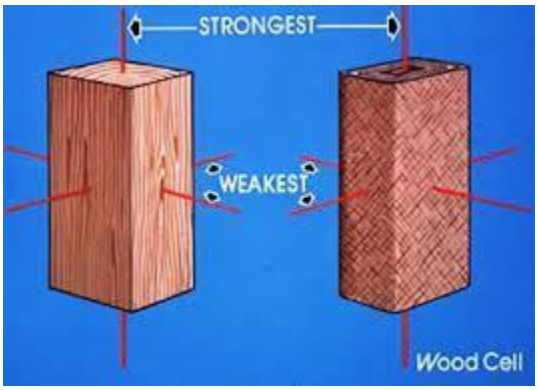


Figure 1.1: Schematic Diagram of Breaking Strength of Wood

Advantages of three-point and four-point bending tests over uniaxial tensile tests include: simpler sample geometries, minimum sample machining is required, simple test fixture, possibility to use as-fabricated materials and the disadvantage is more complex integral stress distributions through the sample.

Tension and compression parallel to grain properties are found by applying an axial force to a test piece having a full-size cross-section and sufficiently long to provide a test length clear of the grips. For perpendicular to grain tests, the test piece dimensions are prescribed. In all cases, the deformation is measured over a central gauge length[24]. The modulus of elasticity is determined from the slope of the load-deformation curve. The tension or compression strength is found by dividing the failure load by the cross sectional area. This can determined using a hydraulic press. A hydraulic pressing machine is a device for lifting heavy weights for applications with much

lower forces. Hydraulic presses are machines or presses that can generate compressive forces by using a hydraulic cylinder.

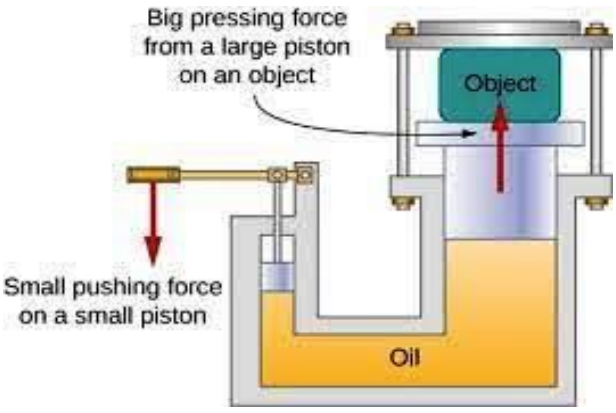


Figure 1.2: Showing Hydraulic Press

Hydraulic Press have the following Advantages; built-in overload protection, it is safe compared to mechanical press, it is compact, lower tool cost due to built-in overload protection, it is quiet in operation, it greater versatility compared to mechanical press, lower initial and operating cost and it offers a full power stroke [24].

Although Hydraulic presses have large number of advantages but there are some disadvantages too, handling of hydraulic oil can be messy, hydraulic lines could burst due to excess pressure, some hydraulic fluids can catch fire, there are chances of hydraulic fluid leakage, system gets heated because the hydraulic fluid is forced through the pumps, it has low operational speed and they have relatively high energy consumption.

Methods and materials

Study setting

Walukuba is a village in Jinja, Eastern Uganda, Uganda, East Africa, Africa and has an elevation of 1,165 metres. is at a latitude of $0^0 26' 50''$north, longitude $33°\ 14'\ 12"$ east .Walukuba is situated nearby to the villages Masese II and Kilembe. The neighboring localities are Bugembe village which is $3\frac{1}{2}$km in the north of walukuba, Wairaka is $4\frac{1}{2}$km north east of Walukuba, Buwenda is located 8km north west of walukuba and the south and eastern boarders are occupied

by Lake Victoria. Walukuba has a coverage of $\mathbf{5.221}\boldsymbol{km^2}$ area and had a population density of $\mathbf{6,512}/\boldsymbol{km^2}$ by (2020)

Walukuba is a subcounty with three (3) parishes which include Masese, Walukuba west and Walukuba East and thirty-two (32) villages. It has twenty-one (21) schools of these schools, 3 are public primary, fifteen (15) primary private one secondary government aided one secondary private and one international school (Horizon international school) and one technical institute (Jinja vocational institute)

The suppliers of furniture are Ise- kabugho furniture, Footsteps furniture Company Ltd, Meddy furniture Mpumudde Kamuli road, Halls and Walls Uganda, Malaysia furniture, steel Wood Furniture Ltd, Muti Furniture Kampala, NGOs like Dream of African Charity foundation, Children of Grace, Jinja Educational Trust and Ministry of Education and Sports. In particular, Milicia excelsa type of wood is got from Nabitende – Kaliro, some eucalyptus wood are grown by farmers in Masese. The wood after lumbering is normally seasoned for three weeks to dry under the sheds in the workshop and there after its ready for manufacture of furniture. The primary institutions require averagely 674 furniture – desks and these cost Ugshs.76,686b which amounts to US$20.45b annually [8].

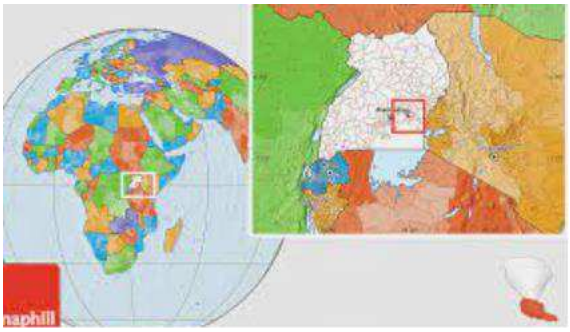


Figure 1.3 map of Africa showing the study area

Research Design

The study employed an experimental research design. The experimental research design was employed because breaking strength of wood were investigated experimentally, where samples were taken to the laboratory and tested.

Sampling techniques

Three different species were examined in the study: *Maesopsis eminii* (*Musizi*), *Eucalyptus* (*Kalitunsi*) and Markhamia (*Musambya*). The woods were obtained from commercial suppliers in workshops in Walukuba division, Jinja City, Kangulumira trading centre and others were obtained from Banda - Kyambogo Uganda. Three (3) specimens per type of timber were made to perform in investigating the breaking strength. The experiment was done at physics laboratory of Kyambogo University.

All the specimen tests were performed on a 50-kN-capacity universal testing machine in the mechanical test laboratory of the Engineering Department of Kyambogo University. Modulus of elasticity values was calculated in accordance with BSEN338 (2003).

Each of the wood specimens was sized at 7 mm by 30 mm in thickness and breadth, to obtain equal cross-sectional areas for all the samples and a uniform length of 100cm. The specimens were loaded at the center point by a standard bearing block

Procedure for Determination of the Breaking Strength

The specimens were clamped on a high table of about 70cm high with the broadest area facing up wards at a distance of about 2cm using the G- clamp, the free end was attached to a light pointer (optical pin) pointing on a vertical meter rule clamped vertically on a retort stand with the graduated face directed to the pin.

The initial pointer position (P_o) was obtained on the vertical meter rule then a slotted mass of 100g was attached at the extreme of the free end of the wooden rod and a new pointer reading(P_1) was obtained the extension was calculated from the equation $e = P_1 - P_0$ this was repeated for masses of 200,300,400,500, and 600g the corresponding extension was determined and recorded in the tables of results.

The average values of the pointer readings and extensions were determined and a single combined table for the three samples of Eminii, Eucalyptus and Markhamia was obtained which was used for determining the young's modulus of different wood species.

The breaking strength of different types of wood was obtained by calculating the modulus of elasticity (Young's modulus of elasticity) using the formulae

Young's modulus $= \frac{stress}{strain}$ ……..1.5

$y = \frac{l}{A}S$ ……1.6

Since $A = tb$ *and* $s = slope\ of\ the\ graph$

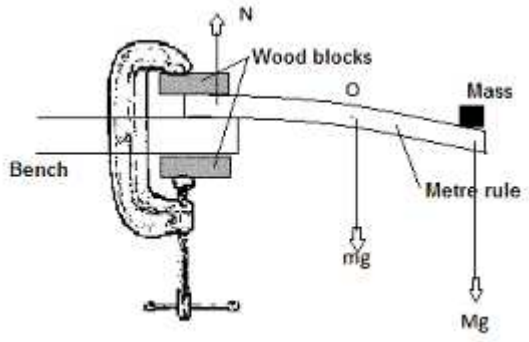


Figure 1.3: Experimental setup

Validity and Reliability

Validity of results was achieved by testing three samples per wood species and their average breaking strength taken while reliability was ensured by testing for the accuracy of the machine before it was used in the experiment.

Data Analysis

The results were recorded in a table of results using relevant software like Microsoft Excel and Mat lab. Tables of results for each of the wood sample were generated and this was used to plot relevant graphs.

Sample table of results

Mass (kg)	**Extension (cm)**								
	Extension of Musizi			**Extension of Eucalyptus**			**Extension of Markhamia**		
	e_1	e_2	e_3	e_1	e_2	e_3	e_1	e_2	e_3

RESULTS

In our study, we worked on three (3) tree species. Namely Eucalyptus globus (Eucalyptus), maesopsis eminii (musizi) and markhamia lutea (markhamia)

These trees were obtained from Kangulumira kisega workshop in which we picked 5pieces of markhamia representing 33.3%, walukuba/masese in a workshop we obtained 5pieces of Eucalyptus representing 33.3%, and in Banda-Kyambogo Kampala where we got the other 5 pieces of Musizi 33.3%

The age of the different species included;4, 5 and 3 years respectively for Eucalyptus, Musizi and Markhamia and they had lasted averagely 21days before our experiment.
Regarding extension of the different tree species, our results showed that increase in force led to an increase in extension of the Markamia sample 1 from initial force of 0.981N to maximum 5.886N while the extension increased from the initial of 5.6cm to maximum of 39.3cm. Considering the slope of 42.286cmkg^{-1}, the young's modulus for Markamia was 709.72Nm^{-2}(Figure 1). For Musizi wood under the same force the initial extension was 5.2 and it increased with increase in force to a maximum of 26.6cm thereby giving a slope of 42.286cmkg^{-1}, this gives a young's modulus of 1164.37Nm^{-2}. Furthermore, when a force increases from a minimum of 0.981N to a maximum of 5.886N, the extension also increases from a minimum of 3.1cm to a maximum of 21.7cm giving a slope of 37.257cmkg^{-1} this gives a young's modulus of 1267.27 Nm^{-2}.

Regarding the Young's modulus of different wood types varying extension and length while keeping the cross-sectional area constant, Results show upward sloping curves denoting that reduction in length leads to a proportional decrease in extension of the Markamia, Musizi and Eucalyptus wooden rods. At an initial length of 0.900 m, the extension was 24.5cm for Markamia, 18.0cm for Musizi and 13.0cm for eucalyptus thus eucalyptus wooden rod attained the minimum extension at 1.0cm, Markhamia attained a minimum extension of 3.2cm while musizi attained a minimum extension of 2.0cm at the length of 0.300m. basing on the slope of each graph, Young's modulus was determined using the slope and it was established that the Markamia had a young's

modulus of 709.72Nm^{-2}, Musizi had a young's modulus of 1164.37 Nm^{-2} and Eucalyptus had the highest Young's modulus of 1267.27 Nm^{-2} (Figure 4.2).

Tables of Raw Results

Table 1: Thicknesses for different tree species

Wood type	**Thickness**			
	t_1(mm)	t_2(mm)	t_3(mm)	t(mm)
Musizi rod	6.70	6.80	6.81	6.77
Eucalyptus rod	7.10	7.05	7.02	7.06
Markhamia rod	6.68	6.64	6.69	6.67

Table 1: Results for different tree species

M(kg)	Musizi		Eucalyptus		Markhamia	
	P av.(cm)	e(cm)	P av.(cm)	e(cm)	P av.(cm)	e(cm)
0.100	32.6	5.2	31.9	3.1	31.8	5.6
0.200	37.7	10.2	35.8	6.9	36.6	10.5
0.300	42.7	14.9	39.6	10.7	40.7	14.6

0.400	45.8	18.4	43.1	14.2	53.4	27.3
0.500	50.1	22.7	47.1	18.2	58.4	32.3
0.600	54.0	26.6	50.6	21.7	65.1	39.3

Table 3: Final combined table of results

M(kg)	e_{musizi}(cm)	$e_{eucalyptus}$(cm)	$e_{markhamia}$(cm)
0.100	5.2	3.1	5.6
0.200	10.2	6.9	10.5
0.300	14.9	10.7	14.6
0.400	18.4	14.2	27.3
0.500	22.7	18.2	32.3
0.600	26.6	21.7	39.3

Table 4: Young's Modulus of different tree species varying length and extension

Length (cm)	Musizi		Eucalyptus		Markhamia	
	P_1(cm)	e(cm)	P_1(cm)	e(cm)	P_1(cm)	e(cm)
90	45.5	18.0	43.0	13.0	50.3	24.5

80	41.5	14.0	40.5	11.0	48.3	22.5
70	40.0	12.5	38.5	9.0	44.0	18.2
60	37.7	10.2	36.0	6.5	40.3	14.5
50	36.0	8.5	34.5	5.0	36.0	10.2
40	33.0	5.5	32.5	3.0	32.2	6.4
30	29.5	2.0	30.5	1.0	29.0	3.2

Table 5: Combined table of results for young's modulus varying length and extension

L(cm)	e_{musizi}(cm)	$e_{eucalyptus}$(cm)	$e_{markhamia}$(cm)
90	18.0	13.0	24.5
80	14.0	11.0	22.5
70	12.5	9.0	18.2
60	10.2	6.5	14.5
50	8.5	5.0	10.2
40	5.5	3.0	6.4
30	2.0	1.0	3.2

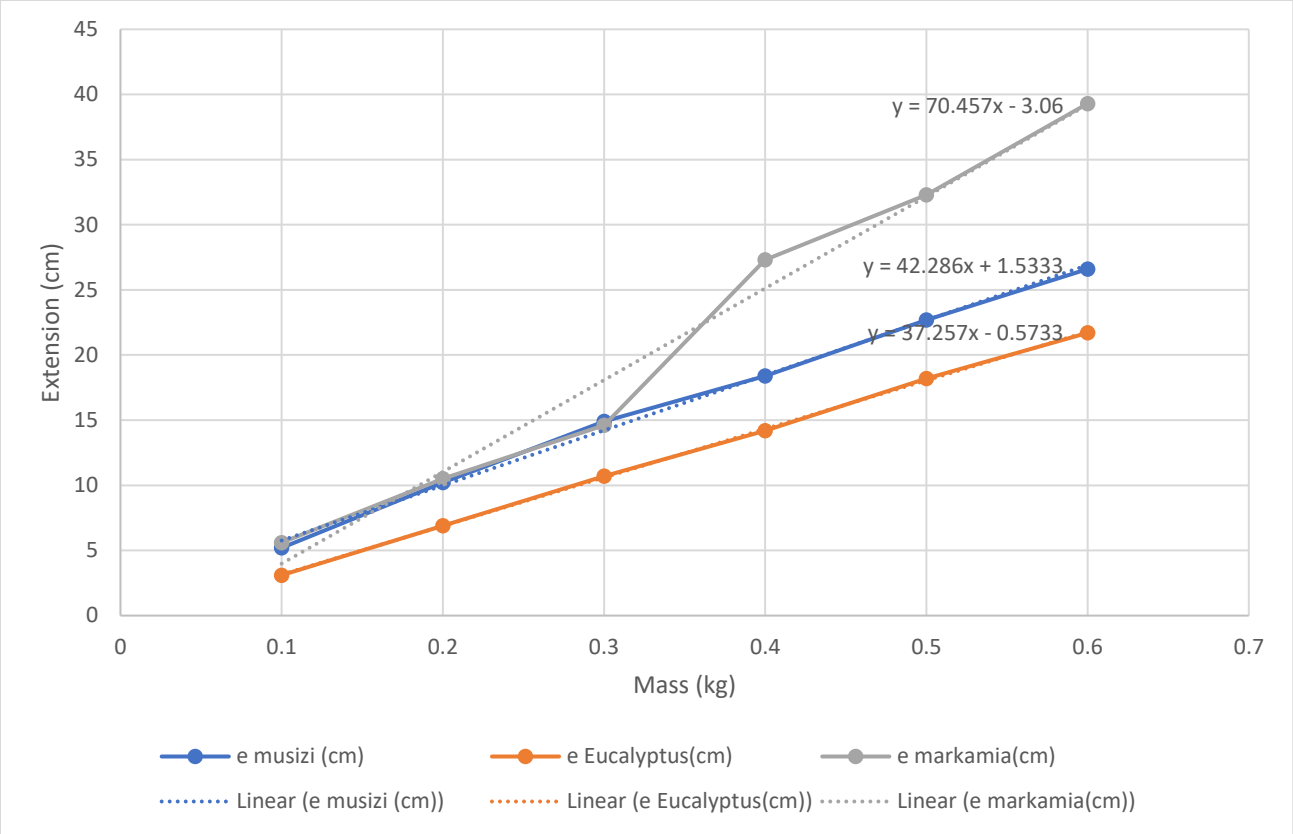


Figure 1.5: A graph of Extension against Mass

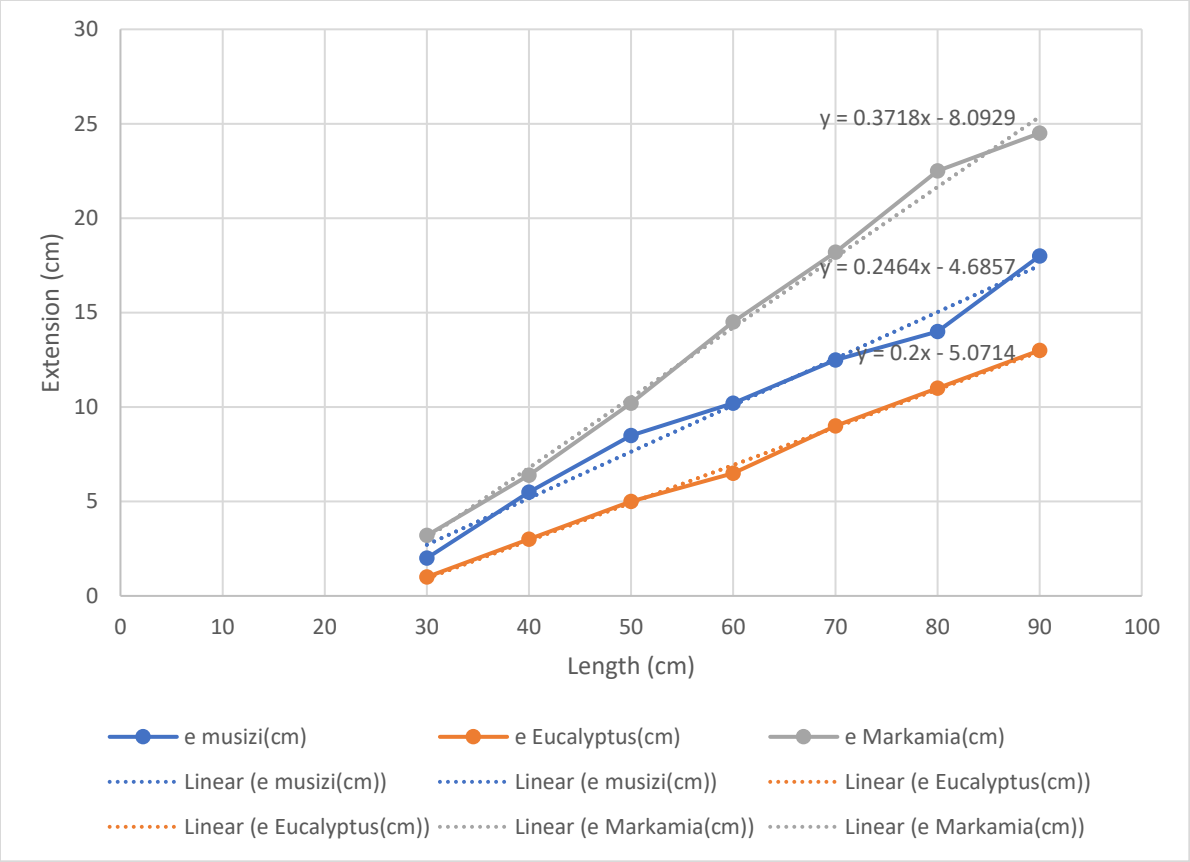


Figure 1.6: A graph of Extension against Length

Discussion of results

The objective of the study was "to investigate the breaking strength of wood in Walukuba Division Jinja Municipality" in this study the young's modulus of Eucalyptus globus was 1267.27Nm^{-2}, maesopsis eminii was 1164.37Nm^{-2} And that of markhamia lutea was 709.72Nm^{-2}

Eucalyptus normally grows to 300ft in Tasmania and around 160ft in Africa is the most preferred tree species for reforestation in Thailand, USA, and in Africa due to its mechanical properties like high MOE and low MOR hence very suitable for pulp production. (futoshi. I. et al, 2013) in our experiment, we got the its young's modulus to be 1267.27Nm^{-2} other scholars have 11.72GPa and the standard one is 16.64GPa. (futoshi. I. et al, 2013)

Maesopsis eminii usually attains a height of 50 to 90ft in U.S.A but it goes up to 150ft in Kenya and Uganda (7)., its rated as soft wood it has thick and slivery gray bark (8) in our experiment we found out that young's modulus was 1164.37Nm^{-2} other scholars have it as 1250$Nm^{-2}$when its

fresh and 1430$Nm^{-2}$when its air dry (FPL, 2001). This variation is in the temperatures (humidity) in Africa temperatures go up 35^{o}c which is not the case in USA yest an increase in temperature leads to a decrease in young's modulus of a material (www.sciencedirect.com).

CONCLUSIONS

Generally, it can be concluded that the results of this study provided fundamental information on the Young's modulus of three types of wood sold in Walukuba Division, Jinja Municipality regardless of the variation in the parameters such as force, cross sectional area, extension and length. It emerged that Eucalyptus had the highest young's modulus than the rest of the two wood species under study.

It was also concluded that Eucalyptus timber had the highest young's modulus of elasticity of followed by Musizi and then Markhamia with the lowest when varying force and extension while keeping length and area.

In line with the above, it was also concluded that Eucalyptus had the highest young's modulus when varying length and extension, keeping force and area constant followed by Musizi wooden rod and lastly Markhamia wood rod when varying extension and length keeping cross sectional area and force constant.

RECOMMENDATIONS

The study recommends that there is need to encourage people especially construction engineers to use trees with high stiffness as a controlling factor and where strength requirements are so critical. The researcher also recommends that the Eucalyptus tree species should be promoted and encouraged for use since it can withstand more weight than Musizi and Markhamia.

There is also need to assess the quality of various timber species on Uganda's market by Uganda National Bureau of Standards (UNBS) for quality assurance in timber trade and utilization.

Recommendation for Further Research

The study recommends that there is need for collaborative research involving University academia, UNBS, National Forestry Authority, Uganda Institution of Professional Engineers and other partners to develop local timber standards.

The study recommends that more studies need to be done to determine other properties of *Maesopsis eminii* (*Musizi*), *Eucalyptus* (*Kalitunsi*) and Markhamia (*Musambya*) in terms termite and fire resistance.

Further research should be conducted about other materials which can be used to manufacture seats for students such as steel, aluminum and plastics.

Abbreviations

M.C	Moisture Content
MOE	Modulus of Elasticity
MOES	Ministry of Education and Sports
MOR	Modulus of Rapture
R.H	Relative Humidity
V.O.Cs	Volatile Organic Compounds

Declarations

Ethical approvals and consent to participate

Permission to conduct this study was obtained from the academic committee of Kyambogo university faculty of education as part of the requirements to be fulfilled for the award of a bachelors' degree of science with education and it was granted on 2nd January 2021. An introductory letter explaining the need of the research and benefits of my research was issued by the physics department of Kyambogo university. This letter was presented to kasibanghabo

furniture enterprises in Walukuba and the permission to collect the wood species for the study was granted.

Competing interests

No competing interests

Author's contributions

G.N conceptualized, developed research and mobilized resources L.B helped in collecting analyzing the data N.N.W helped in reviewing the initial stages of the manuscript, made corrections and selected the best journal that suits the manuscript, M.K was the research supervisor and edited the manuscript and offered technical advice about the whole process. All authors read and approved the final version of the manuscript

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Availability of data and materials

All data supporting our findings are contained in the paper. There are no restrictions to the data sources, however details of the full data may be accessed through mr. George Napulu, napgeorgewilly93@gmail.com

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