



SCIENCE TEACHERS ASSOCIATION OF NIGERIA

INNOVATIONS IN SCIENCE, TECHNOLOGY &
MATHEMATICS



Proceedings of
**AJUMOGOBIA MEMORIAL
CONFERENCE**

1997

in Commemoration of the

40TH ANNIVERSARY OF STAN

ADEDAYO O. OLAREWAJU
Editor

UNESCO - Assisted Publication

IMPROVISATION OF MATERIALS IN THE TEACHING OF PHYSICS: A CASE FOR INVESTIGATION OF THE PHYSICAL PROPERTIES OF LOCAL MATERIALS

Fidelis A. Onwioduokit, Ph. D.

Department of Science Education, University of Uyo, Uyo.

Abstract

Improvisation is often discussed and carried out without considering the properties - physical, electrical, magnetic, etc., of the materials. The need to undertake such investigations is underscored in this study. Moreover this study considers the physical properties of two local materials in Akwa Ibom State, commonly known as Tie-tie and piassava, used as local ropes. The materials were used both in their dry and wet states. For Tie-tie, both soft and hard types were used in the experiment. Materials of different lengths and cross-sectional areas were used in laboratory experiments after which the means values of tensile strength and young modulus for each material were computed. The results showed that:

- 1. Piassava is stronger in its wet state than when dry.*
- 2. A soft Tie-tie is stronger than the hard type in both wet and dry states.*
- 3. Tie-tie is stronger than piassava in both wet and dry states.*

Dryness of these materials generally affect their tensile strength. It is therefore recommended that the materials be kept under low temperature for optimum performance.

Introduction

Unlike in Biology where nature serves as the laboratory and where specimens of plants and animals are readily obtained and easily used, materials for the teaching of physics are expensive and usually not readily available. As a result of high cost of physics materials, most schools, especially at this period of austere economy, have not been able to acquire relevant materials for the teaching of the subject. Consequently concepts in physics are shabbily treated to the effect that students have problems understanding most concepts (Onwioduokit, 1996).

A way out of this problem is said to hinge on improvisation of materials (Oladimeji, 1978; and Eshiet and Inyang, 1984). Improvisation is an activity of a resourceful teacher that enables him to use substitutes for expensive and unavailable materials in the course of teaching. It is however necessary to ensure that the substitute materials perform appreciably when compared to the prototype materials. To ensure this, it is crucial to study the properties of the materials to be used as substitutes and for local production of equipments.

Improvisation is often discussed and carried out without considering the properties - physical, electrical magnetic etc, of the materials. This study emphasizes the need to undertake such investigations. specifically, the study investigates the tensile strength of materials called Tie-tie and Piassava commonly used as ropes in the Eastern parts of Nigeria, especially Akwa Ibom and Cross River States.

Purpose of Study

The purpose of the study is to investigate the tensile strength of Tie-tie and Piassava, materials that can be improvised for metal wires in teaching the concepts of "tensile strength" and "young modulus."

Methodology

The study was carried out via laboratory experiments. Piassava and Tie-tie of different lengths and diameters were obtained from their sources using weights of various sizes, extensions of each material were measured with corresponding weights attached. The experiments were conducted using dry and damped materials. The damping was done by submerging the Piassava and Tie-tie in water for one day (a common practice in local areas where the material are used).

Apparatus

The following instruments were used: micrometer screw guage, metre rule, weight hanger, retort and standard weights.

Experiment

For each sample of the material, original length (Lo) as well as the mean diameter were measured and recorded. The material under test was loaded until it just become taut. Then the load was gradually increased with the corresponding lengths of the materials recorded. Loading continued until the material was just about to break. The loads were then gradually removed and the corresponding lengths of the material were recorded. For both loading and unloading, extension of the material at each point was recorded and the mean extension of the material at each point was calculated. The experiment was repeated for different lengths and mean diameters of Piassava and Tie-tie in their dry and damped states. The results are as shown in graphs 1 - 6.

Theory

To obtain the tensile strength and the stiffness (young's modulus) of each material, the following expressions were used;

1. Tensile Stength = $\frac{\text{Maximum force applied before the material breaks}}{\text{Original cross sectional area.}}$

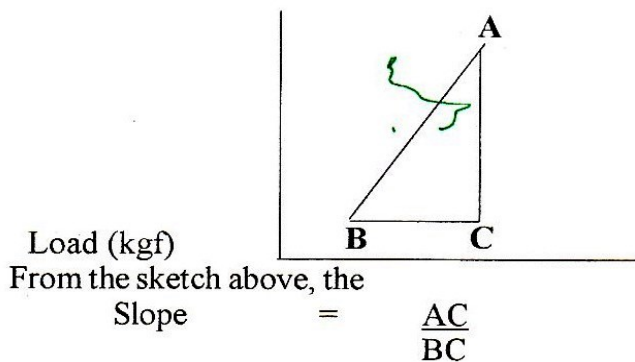
2. Stiffness = $\frac{\text{Tensile Stress}}{\text{Tensile strain}}$

where (a) Tensile Stress = $\frac{\text{Force applied}}{\text{Cross sectional area of the material}} = \frac{F}{\pi r^2}$

where r = radius of the cross section of the material

(b) Tensile Strain = $\frac{\text{Extension obtained (e)}}{\text{Original length (lo)}}$

The value of young's modulus can practically be obtained by plotting a graph of mean extension against the load applied.



$$\text{Young's modulus (E)} = \frac{F}{\pi r^2} \frac{e}{L_0} \dots\dots(1)$$

Where F = Force applied
 e = Extension
 L₀ = Original Length of Material
 r = radius of the cross section of the material

From equation (1) $E = \frac{F}{e} \frac{L_0}{\pi r^2}$

Where $\frac{F}{e} = \frac{1}{\text{Slope}}$

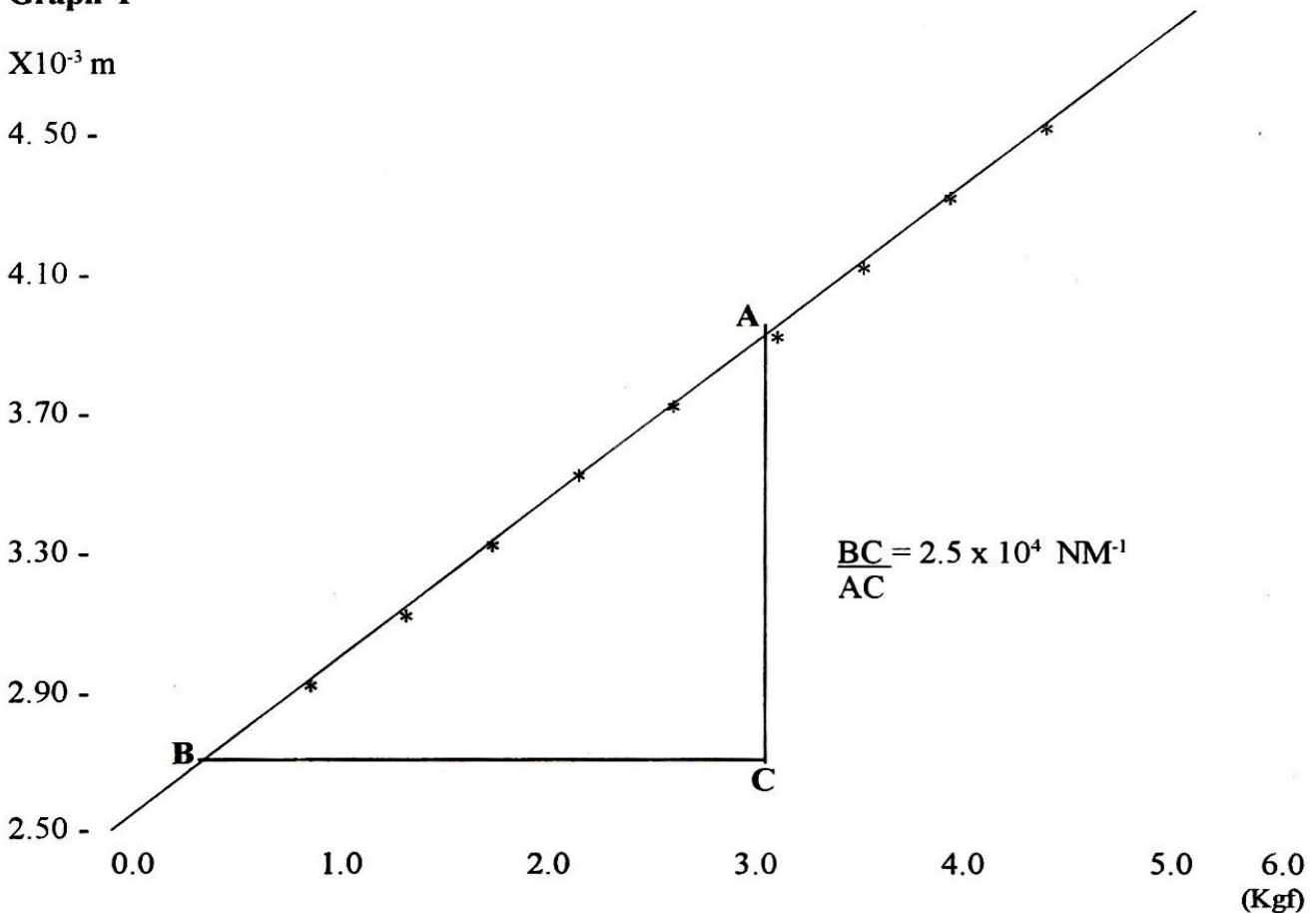
Hence $E = \frac{1}{\text{Slope}} \frac{L_0}{\pi r^2} \dots\dots(2)$

Results and Discussion

Graph 1

A plot of extension (e) against force applied (F) using a dry Piassava of length of 0.81 metres and means diameter of $7.42 \times 10^{-3} \text{m}$ with a breaking stress of 5.00 kgf

Graph 1



As shown in graph above, the slope is $3.87 \times 10^{-5} \text{MN}^{-1}$. The reciprocal of which is $2.58 \times 10^4 \text{NM}^{-1}$. Based on this the following calculations are made:

A case for Investigation of the Physical Properties of Local Materials

1. Tensile strength of dry Piassava =

$$\frac{Mg}{\pi r^2} = \frac{4.50 \times 9.81}{3.142 \times (3.71 \times 10^{-3})^2}$$

$$= 1.02 \times 10^5 \text{ NM}^{-2}$$

2. Young's Modulus =

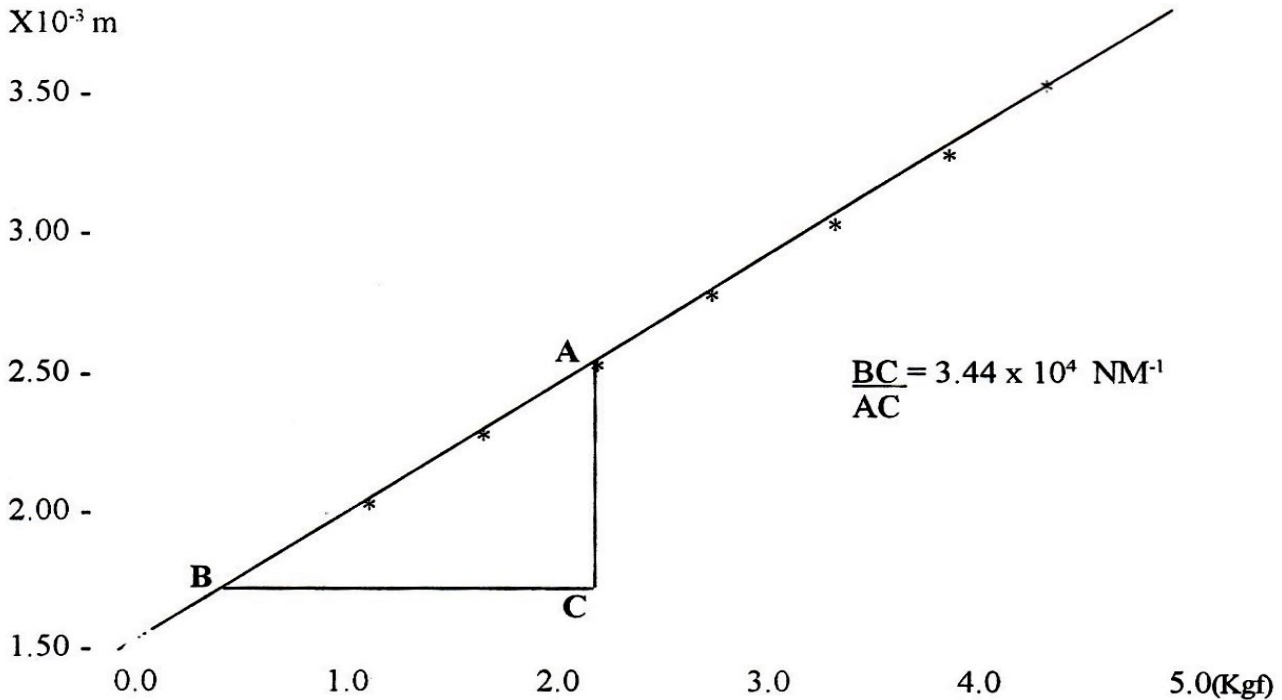
$$\frac{1}{\text{Slope}} \times \frac{L}{\pi r^2}$$

$$= \frac{2.58 \times 10^4 \times 0.81}{43.25 \times 10^{-6}}$$

$$= 4.83 \times 10^8 \text{ NM}^{-2}$$

Graph 2

A plot of extension (e) against the force applied (F) using a damped Piassava of length 0.97 metres and of mean diameter of 7.70×10^{-3} with breaking stress of 5.50 kgf



The slope of graph 2 is $2.91 \times 10^{-5} \text{ MN}^{-1}$, giving a reciprocal of $3.44 \times 10^4 \text{ NM}^{-1}$ consequently.

1. Tensile strength of damped Piassava

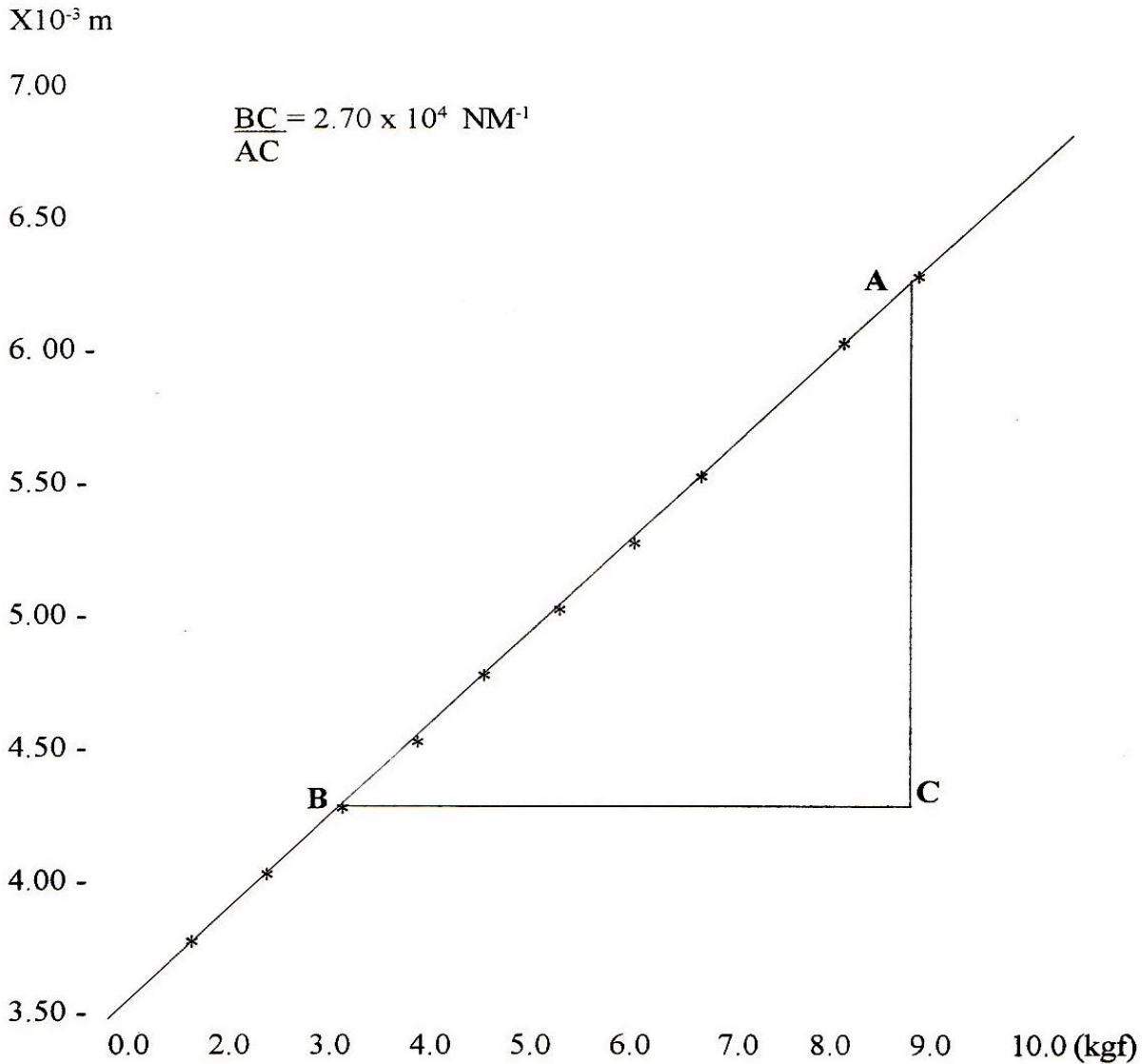
$$= \frac{5 \times 9.81}{46.57 \times 10^{-6}} = 1.05 \times 10^6 \text{ NM}^{-2}$$

2. Young's modulus of dry Piassava

$$= \frac{3.44 \times 10^4 \times 0.97}{46.57 \times 10^{-6}} = 7.17 \times 10^8 \text{ NM}^{-2}$$

Graph 3:

A graph of extension (e) against force (F) applied using a dry Tie-tie (hard type) of length 1.12m and mean diameter 2.04×10^{-3} m with breaking stress of 10.50 kgf



Graph 3 gives a slope of $3.71 \times 10^{-5} \text{ MN}^{-1}$ with the reciprocal of $2.70 \times 10^4 \text{ NM}^{-1}$

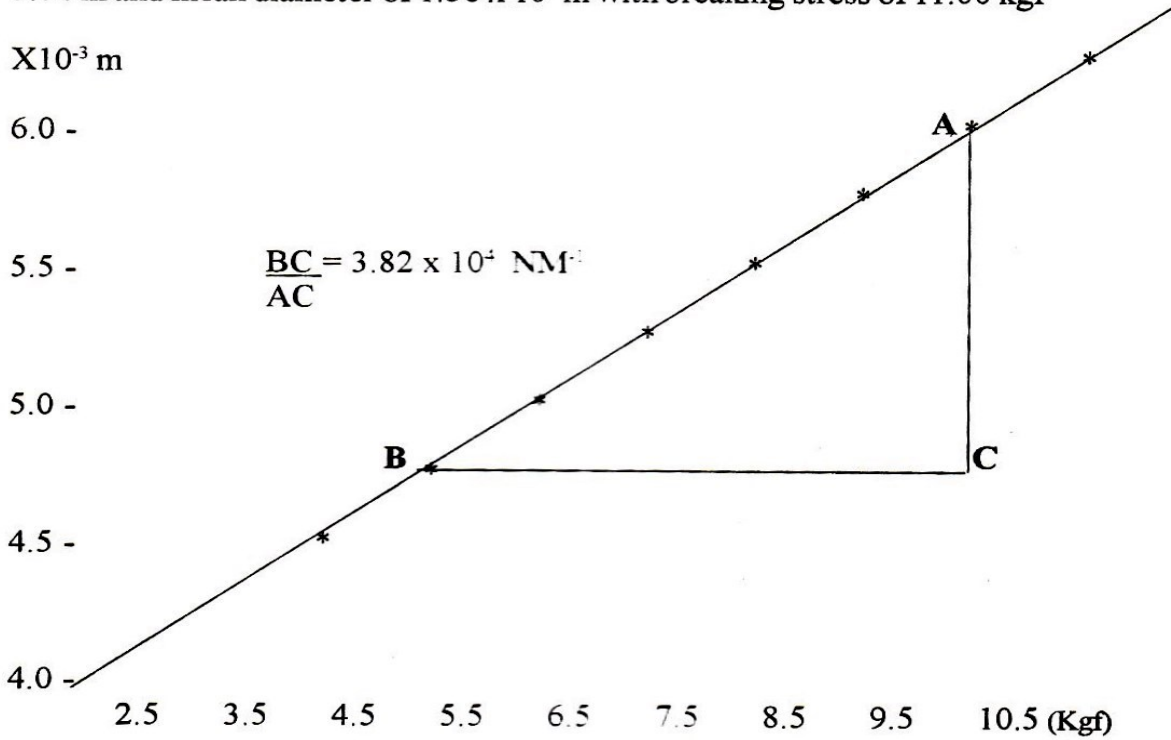
Hence the Tensile strength of the hard type of dry Tie-tie is given as

$$\frac{10.0 \times 9.81}{3.27 \times 10^{-6}} = 3 \times 10^7 \text{ NM}^{-2}$$

Similarly its young's modulus is given as

$$\frac{2.70 \times 10^4 \times 1.12}{3.27 \times 10^{-6}} = 9.25 \times 10^9 \text{ NM}^{-2}$$

Graph 4: A plot of extension (e) against the force applied (F) using a dry Tie-tie (Soft type) of length 1.04 m and mean diameter of 1.56×10^{-3} m with breaking stress of 11.00 kgf



The slope of graph 4 is 2.61×10^{-5} MN yielding a reciprocal of $3.82 \times 10^4 \text{ NM}^{-1}$

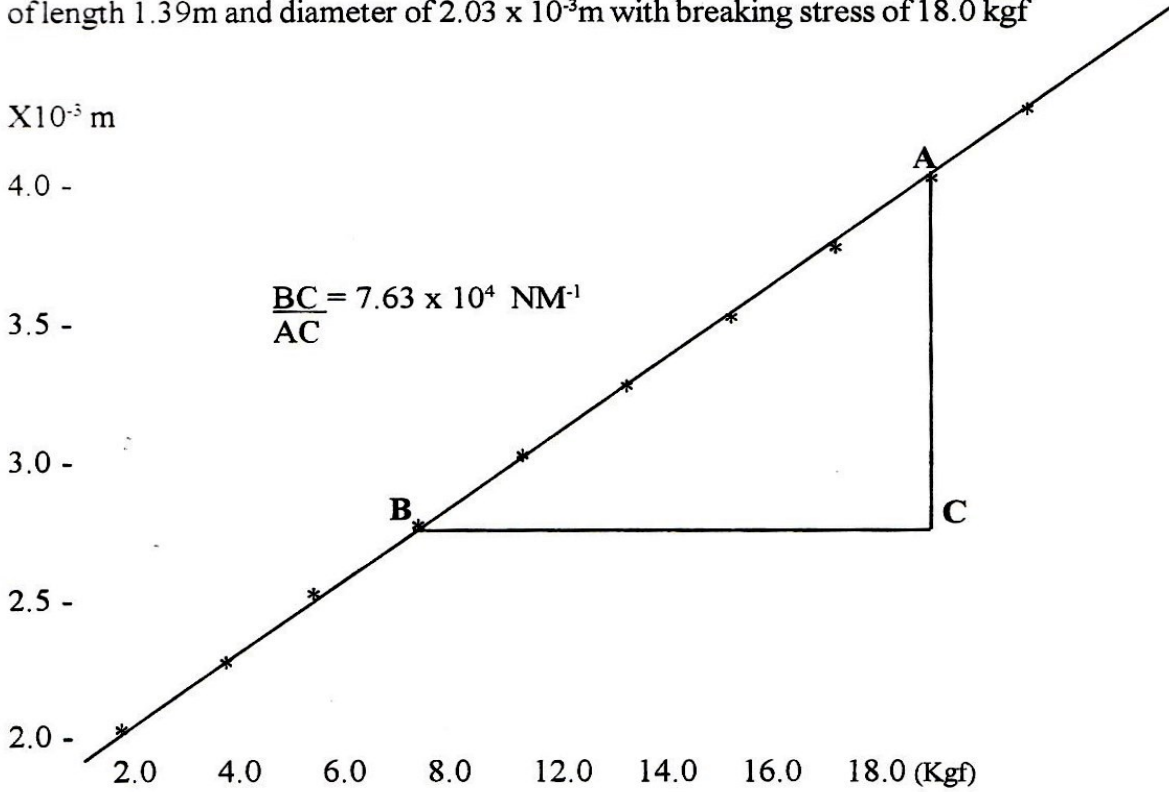
The Tensile strength therefore is

$$\frac{10.50 \times 9.81}{1.91 \times 10^{-6}} = 5.39 \times 10^7 \text{ NM}^{-2}$$

$$\text{Young's modulus} = \frac{3.82 \times 10^4 \times 1.04}{1.91 \times 10^{-6}}$$

$$= 2.08 \times 10^{10} \text{ NM}^{-2}$$

Graph 5: A plot of extension (e) against the force applied (F) using a damped Tie-tie (hard type) of length 1.39m and diameter of 2.03×10^{-3} m with breaking stress of 18.0 kgf



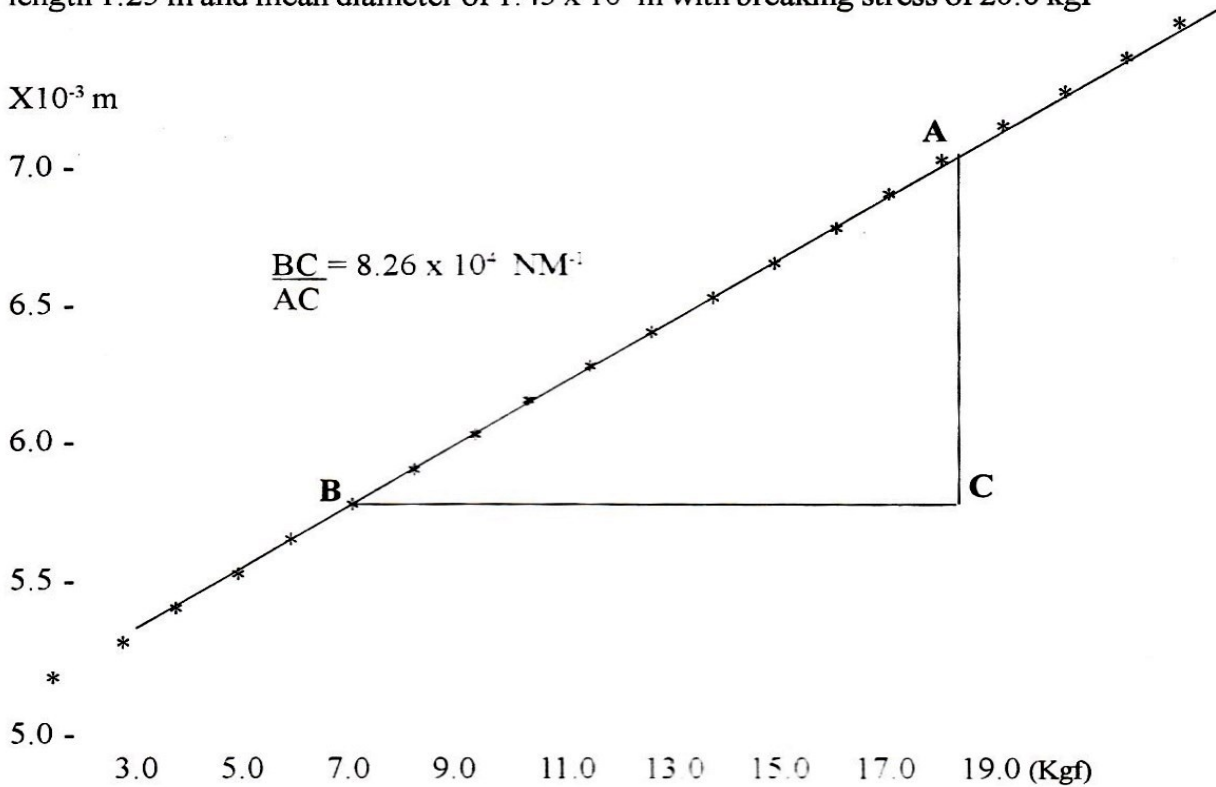
From Graph 5, using the slope of $1.31 \times 10^{-5} \text{ MN}^{-1}$ and its reciprocal of $7.63 \times 10^4 \text{ NM}^{-1}$, Tensile strength of a damped hard type Tie-tie is given as

$$\frac{17.5 \times 9.81}{3.27 \times 10^{-6}} = 5.25 \times 10^7 \text{ NM}^{-2}$$

Accordingly, its young's modulus is given as

$$\frac{7.63 \times 10^4 \times 1.39}{3.27 \times 10^{-6}} = 3.24 \times 10^{10} \text{ NM}^{-2}$$

Graph 6: A plot of extension (e) against the force applied (F) using a damped (Soft type) Tie-tie of length 1.25 m and mean diameter of 1.45×10^{-3} m with breaking stress of 20.0 kgf



As shown in Graph 6, the slope is given as $1.21 \times 10^5 \text{ MN}^{-2}$ giving the reciprocal of $8.26 \times 10^4 \text{ NM}^{-1}$. The Tensile strength of a damped soft type Tie-tie is therefore given as:

$$\frac{19.5 \times 9.81}{3.142 \times 5.26 \times 10^{-7}} = 1.16 \times 10^8 \text{ NM}^{-2}$$

In the same way, its young's modulus

$$\frac{8.26 \times 10^4 \times 1.25}{1.65 \times 10^{-6}} = 6.26 \times 10^4 \text{ NM}^{-2}$$

The summary of all the results is given in Table 1 as follows:

Table 1: Tensile Strength and Young Moduli of dry and damped Piassava and Tie-tie (Soft and hard type)

Material	State	TensileStrength (NM-2)	Young's Modulus (NM-2)
Piassava	dry	1.02×10^6	4.83×10^8
Piassava	damped	1.05×10^6	7.17×10^8
Tie-tie (hard type)	dry	3×10^7	9.25×10^9
Tie-tie (soft type)	dry	5.39×10^7	2.08×10^{10}
Tie-tie (hard type)	damped	5.25×10^7	3.24×10^{10}
Tie-tie (soft type)	damped	1.16×10^8	6.26×10^{10}

Conclusion

The experiment to determining the tensile strength and young moduli of Piassava and Tie-tie (materials used as ropes in most parts of the Eastern States of Nigeria) has shown that these materials have higher

tensile strength and young moduli in their damped states than when dry. This observation emanates from the fact the apart from expansion effect, temperature does influence the strength of materials. It is known that the strength of a material decreased with an increase in temperature (Wenham, Dorling, Snel and Taylor, 1978).

The prevent study also shows that a soft Tie-tie is stronger that the hard type. Tie-tie was also found stronger than Piassava in all states.

With the knowledge of strength of these materials, Tie-tie and Piassava could be meaningfully used as substitutes for the demonstration of concepts of the "tensile strength" and "young modulus" in physics. The need for such knowledge cannot be overemphasized.

For a more comprehensive knowledge of the properties of these materials, it is recommended that their electrical and magnetic properties be studies. Moreover, for optimum performance, Piassave and tie-tie should be kept at low temperature.

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