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Examination of Nigerian Economy Veneered Engineered Wood Bending Modulus for Sustainable Development

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ABSTRACT **Original Research Article**

Due to loss of resources as a result of failure associated with using indecorous veneered engineered wood (Plywood) product in Nigerian economy and rarity of technical information to avert such loses with respect to their bending modulus, technical insights relevant to prevent such loss due to choice of improper quality for abundant needs was investigated. Prepared and subjected to four tests per sample as required by a universal testing machine (UTM), the testometric testing machine were the three most sought after veneered engineered wood (Plywood) following their identification. Aggregate average statistics for each sample were determined. Caledonian, Plywood EQ and Viewpoint had their bending modulus as 5118.664(N/mm^2), 2198.810(N/mm^2) and 226.941(N/mm^2) respectively. Statistics show that in veneered engineered wood (Plywood), the bending modulus for Caledonian is 132.79% and to the extent of 2155.50% more superior than that of Plywood EQ and Viewpoint respectively. Bending modulus for Plywood EQ is 868.89% more suitable than that of Viewpoint. From the generated data, chats on the dynamics of the bending modulus of the samples were ensued by computer program. These showcase potentials of the material's resistance to bending which actually is a measure of how stiff a material is when subjected to bending forces. This sustainable avant-garde technical understanding of bending modulus of veneered engineered wood (Plywood) product in Nigerian economy should be valued by architects, building contractors, engineers, individuals, construction companies as well as furniture makers. Engineers in the Biomedical areas as well as equipment developers and Engineers in general can as well utilize this knowledge. Bending modulus of other materials used together with engineered wood products should form future research works.

Keywords: Elasticity, Elongation, Flexure Strength, Mechanical Test, Resilience.

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1. Introduction

Background of the Study

Forestry products industrial goods exports were relished by Nigeria in the 1950's, 1960's and 1970's according to (Ogunwusi, 2012). A derivative of wood product, engineered wood products are typically obtained through the processes of binding particles, the strands, fibers, or boards of wood together. Fasasi, Baba and Ogunmilua, (2024) noted that engineered wood products have been known to offer dimensional stability, enhanced mechanical properties as well as durability that streamline improved energy performance and larger complex structural elements. At the global scene (FMRL, 2025) observed that with the global engineered wood market valued at USD 50.2 billion in 2024, it is expected to grow from year 2025 at a compound annual growth rate (CAGR) estimate of as much as 4.5% with projection to reach USD 74.5 billion by the year 2033. FMRL, (2025) again noted that Nigerian engineered wood market was valued at USD 8.81 billion in 2023 and is expected to grow at a CAGR of 3.3% to reach USD 11.05 billion by 2030. Used comprehensively across packaging industries, furniture, and construction, wood composite in Nigeria remains a vital engineered wood product. It is quite unfortunate that, Nigeria as at present mostly remain heavily dependent on engineered wood imports despite abundant raw materials and a fast-growing domestic market.

Engineered wood products are achieved by the use adhesives, typically engineered to certain specifications resulting in a material that can have diverse applications, Production of engineered wood products, highlights the reduction in the need to fell old-growth forests as they are commonly made by the use of wood waste materials. Facilitating optimal processing conditions, comparable engineered wood products can also be made from vegetable fibers using lignin-containing materials as well as chemical additives to enable the integration of polymer and wood flour. Mechanical properties improvement is usually remarkably observed with combination of the alkali treatment followed by silanization at the production of highly environmentally-friendly engineered fiberboards by a partially biobased epoxy resin as binder and hot-press molding using Posidonia oceanica wastes, (Garcia-Garcia, et al. 2018). Particle and fiberboards that are usually made of materials like rye and wheat straw, sugar cane residue, hemp stalks e.t.c, are widely used in the building industry as eco-friendly solutions to wood with increasing uses in ceiling boards, wall partitions and thermal insulators e.t.c, due to an excellent combination of mechanical, thermal and acoustic properties together with a competitive price, (Garcia-Garcia, et al. 2018).

Despite these pros, there are some cons associated with the use of engineered wood products. Due to higher chemical heat content and melting properties of composites regardless of all these advantages, higher fire hazards could be experienced when a comparison is made between engineered wood product and solid wood products. Humidity-induced warping which is not common in solid woods when exposed to moisture is a common experience in engineered wood product that are fiber-based and particle-based. When cheap and commonly used resins in the engineered wood product are usually made with urea-formaldehyde bonded products which usually release toxic formaldehyde from the finished products, a strong apprehension with engineered wood product is formed. The inflation rate and the prices of building materials in Benin city was analyzed from a correlation analysis and it showed that inflation was the most influential factor responsible for increase in the cost of building materials with the inflation rate in Nigeria having a direct relationship with the prices of the building materials thus the cause for the high cost of building materials, (Obaedo 2024). A very strong relationship exists between rate of residential development and building materials prices when the effect of building materials cost on housing development in Owerri, Imo state, eastern region of Nigeria was analysed, (Igboekulie, Monye, and Joseph, 2022). In the critical study of inflation trend pattern and its impact on Nigeria’s economy, (Barguma, et al, 2022) reveled that the economy, especially building materials market was badly hit by the inflation with the purchasing power of the Nigerian currency, Naira seen to be decreasing. All these challenges not withstanding due to remarkable improvement on esthetic and mechanical properties of the resulting engineered wood products, their demand is interestingly noted to be on the rise as projected by the earlier statistics. This in essence calls for a prudent use of the resources. As an objective aimed towards sustainable economic development, it becomes imperative to study bending modulus of veneered engineered wood (Plywood) product in Nigeria as the technical insight provided will significantly go a long way to prevent heavy loss of revenue due to use of indecorous quality for various needs thereby enhancing the economy.

Bending Modulus

The bending modulus (or modulus of elasticity in bending) is a critical engineering parameter for engineered wood composites. This is because it directly quantifies the material's stiffness and resistance to deflection under load. Bending modulus (or flexural modulus) measures a material's resistance to bending or flexure. The bending modulus of wood composites is like a measure of how stiff or rigid the material is when bent. Think of one bending a wooden ruler, it won’t bend much when it’s very stiff. It bends easily when it’s more flexible. It's calculated from the ratio of stress to strain in bending, indicating stiffness. This property is fundamental to ensuring the safety, serviceability, and performance of structures built with these materials. Accurate bending modulus values are essential inputs for computational simulations, such as finite element analysis (FEA), which engineers use to model and predict the complex behavior and stress distribution of components before physical prototyping. In research and development, understanding the bending modulus of novel engineered wood composites (like cellular beams or fiber-reinforced panels) is crucial for validating their structural performance and comparing them to traditional materials like glulam or solid wood. Engineered wood products are used in various applications. In construction, majorly in framing, flooring, walls, roofs. Secondly in furniture, from cabinets making to tables, chairs, especially in medicals. In packaging, they form good materials for crates as well as pallets. They are also commonly used in interior design like panels, mouldings and trims.

2. Review of Literature

To establish the effect of felling trees at an unripe age, (Ojo and Idieunmah, 2021) found a linear relationship with strength properties of timber, increasing both the compression and shear strengths and even to a reasonable extent the bending strength alongside the age of the timber. The flexural strength of glued laminated beams made from local wood species bonded with phenol resorcinol formaldehyde, urea-formaldehyde adhesives and polyurethane was assessed, (Ekundayo, Arum, and (Owoyemi, 2022) found that the values in glulam beams are significantly higher than the control (custom wood) especially in edgewise direction. Akinyemi, Afolayan and Oluwatobi, (2016) studied the properties of developed composite corn cob (CC) and sawdust (SD) particle boards using 0%, 25%, 50%, 75% and 100% variations for both agricultural wastes using formaldehyde as binder at constant volume, the result showed that the panels with 50% CC had the most preferred performances for both physical and mechanical properties. Courard, et al (2012) found out that a modification of surface quality was noticed after 80 reuses with marine plywood formworks while such changes were observed after 50 reuses with oriented strand board (OSB) panels formworks while studying the evolution of surface properties of concrete through measured lightness and absorption. Iloabachie, Obiorah and Anene, (2018) studied the effects of carbonized coconut shell (CS) volume fraction on mechanical properties of unsaturated polyester resin (UPR) composite and the mechanical properties tests results show that flexural strength and elongation at break increased as coconut shell proportion got increased. Ihueze, Achike, and Okafor (2016) studied the performance characteristics and reinforcement combinations of coconut fibre reinforced high density polyethylene (HDPE) polymer matrixes at optimum condition of volume fractions and particle sizes of coconut fibre-filler and found that coconut fibre reinforced HDPE has 28.6 mega pascal as optimum value for flexural strength. Iloabachie, et al (2017) found that maximum flexural and ultimate tensile strength were attained at 20 wt% for the 425 microns when the effect of particle size on the ultimate tensile strength, flexural strength, density and water absorption characteristics of uncarbonized coconut shell/unsaturated polyester composites of particle size 425 microns sample and 170 microns sample were investigated.

Reviewing from very recent studies, (Ilo, Okoye, and Ugama, 2025), while assessing the Medium Density Fibreboard (MDF) engineered wood load strain in Nigerian found that statistically, MDF Hokusan ability to elongate at break is 35.9526% and 57.8750% better than that of Richard Russel and SKG Nordic respectively, placing MDF Hokusan advantaged while Richard Russel elongation potential over SKG Nordic is just 16.1250%. Marine Plex marine board plywood had ultimate bending strength of 17.96 N/mm^2, Nplex marine board plywood recorded 21.502 N/mm^2 while Super Plex marine board plywood had the best flexural strength at peak of 65.84 N/mm^2 according to recent research by (Ilo, Ajibo, and Dim, 2025a). From statistical analysis of wood load strain of high density fibre engineered wood product, (Ilo, Nwachi, and Chukwunyere, 2025) found that Sinoply ability to elongate at break is 544.89% and 507.44.89% more than that of Dabar and Joubert respectively thereby placing Sinoply at an advantage position while Joubert elongation at break potential over Dabar is just 6.16% higher. Joubert (HDF) recorded 15.604 N/mm^2, Dabar (HDF) recorded 32.604 N/mm^2 while Sinoply (HDF) recorded 39.248 N/mm^2 of their flexural strength at peak in a study of the flexural strength of high density fibreboard (HDF) wood composite in Nigerian market by Ilo, Nneji and Igede, (2025). Ilo, Ajibo, and Dim, (2025b) in an experimental analysis of flexural strength of veneered engineered wood (Plywood) in Nigerian commercial sector revealed that Viewpoint plywood recorded 4.956 N/mm^2, Plywood EQ recorded 9.467 N/mm^2 while Caledonian recorded 16.973 N/mm^2 as the maximum stress, modulus of rupture (MOR) each of them can withstand while being bent before failing or rupturing. Eze, Ilo, and Dim, (2025a) showed that Dabar attained aggregate average hardness of 526.50 Leeb Hardness Test (HLD), Sinoply attained aggregate average hardness of 547.50 HLD while Joubert attained aggregate average hardness of 548.50 HLD from the hardness test conducted on high density fibreboards in Nigerian economy. Richard Russel attained aggregate average hardness of 545.75 HLD, Hokusan attained aggregate average hardness of 535.75 Leeb Hardness Test (HLD), while SGK Nordiac attained aggregate average hardness of 558.50 HLD in hardness test analysis of medium density fibreboards MDF in Nigerian market by (Eze, Ilo and Dim, 2025b). Marine Plex attained aggregate average hardness of 364.5 Leeb Hardness Test (HLD), Nplex attained aggregate average hardness of 392.25 HLD while Super-Plex attained aggregate average hardness of 370.75 HLD in a hardness test analysis of marine board in Nigerian economy by (Ilo, Nweke and Nebo 2025). In a hardness test analysis of veneered engineered wood (Plywood) in Nigerian market, (Ilo, Uro, and Edeh, 2025) showed that Plywood EQ attained aggregate average hardness of 459.25 HLD, View Point attained aggregate average hardness of 456.5 HLD while Caledonian attained aggregate average hardness of 407.5 Leeb Hardness Test (HLD). Again (Ilo, Nwanjoku and Olayeye, 2025) found that SGK Nordic had the best ultimate flexural strength of 13.568 N/mm^2, MDF Hokusan (MDF) recorded 1.24 N/mm^2, while Richard Russel had ultimate flexural strength of 12.986 N/mm^2 in a study of flexural strength of medium density fibreboard (MDF) wood composite in Nigerian market.

Summarily, from above it is apparent that research has not been directed towards providing technical information on veneered engineered wood (Plywood) product in Nigerian economy with regards to bending modulus analysis, hence the obvious need for this research paper.

3. Research Methodology

Material

Research was made in Nigerian market on commonly used and major veneered engineered wood (Plywood) product samples in Nigerian economyto value their bending modulus potentials. Most common and three major veneered engineered wood (Plywood) product in Nigerian economywere identified from the survey made. They were selected as samples for test and subsequent analysis. The veneered engineered wood (Plywood) product samples were Caledonian, Plywood EQ and Viewpoint. They are represented accordingly in table 1.

In table 1, the samples are marked “x”, “y” and “z” representing Caledonian, Plywood EQ and Viewpoint. They are all prepared according to the requirement by the machine and tested on the machine one after the other.

Table 1: Veneered engineered wood (Plywood) product samples tested

Sample	x	y	Z
Make	Caledonian	Plywood EQ	Viewpoint

Equipment

Figure 1, a universal testing machine (UTM) the testometric testing machine was used in the test. Actually, it works by clamping down on a sample of veneered engineered wood (Plywood) product samples appropriately conditioned as required by the machine and mounted on it for test. Bending modulus data of the sample tested were generated according to the resistive tendencies of each sample as the jaw moves down.

The samples, (x) representing Caledonian, (y) representing Plywood EQ and (z) representing Viewpoint were all tested on the machine one after the other after being prepared diligently according to the requirement by the testometric machine shown in figure 1. The samples were prepared by cutting to the dimensions of 30 mm x 200 mm so as to fit in with the testing machine as required. Operated by moving the jaw of the TESTOMETRIC TESTING MACHINE down to clamp on the workpiece as earlier stated, that is the conditioned veneered engineered wood (Plywood) product samples, bending modulus of the wood product samples are evaluated during the process. Bending modulus aggregate average statistics of four tests conducted each for Caledonian, Plywood EQ and Viewpoint were spawned. With computer program the dynamics of the bending modulus chats for the test are generated from data obtained. The plot being a function of the samples compositions resulting from their nature is obviously a clear indication of potentials of the material’s resistance to bending which actually is a measure of how stiff a material is when subjected to bending forces. In this case, the material being the veneered engineered wood (Plywood) product samples. The chats generated are analysed under results and analysis below.

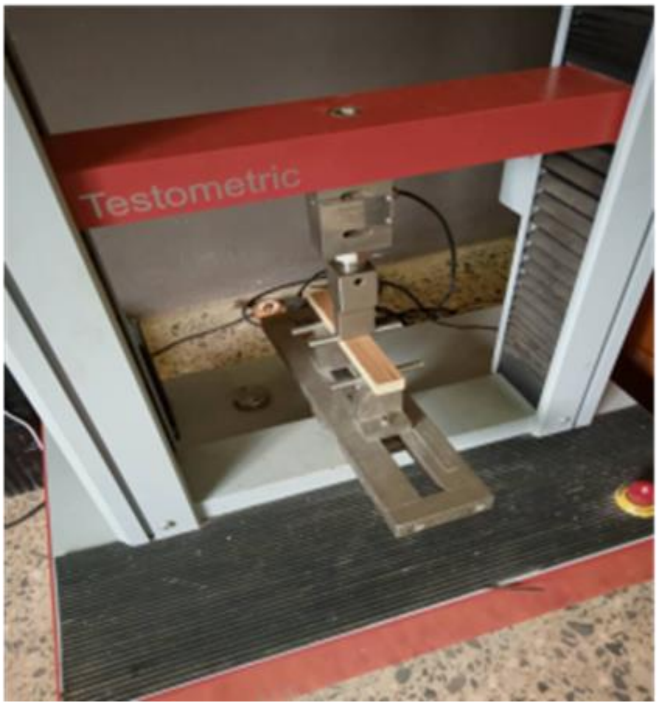

Fig. 1: Testometric machine (A universal testing machine)

4. Results and Analysis

For each of the samples Caledonian, Plywood EQ and Viewpoint, the chats for bending modulus are shown as charts in figures 2, 3 and 4 respectively while figure 5 X rays the bending modulus aggregate average results for Caledonian, Plywood EQ and Viewpoint.

Plots

The figure 2 below is a chart for results for four tests conducted on Caledonian. The data generated did not spread out over a large range which is an indication of homogeneity of the sample, Caledonian.

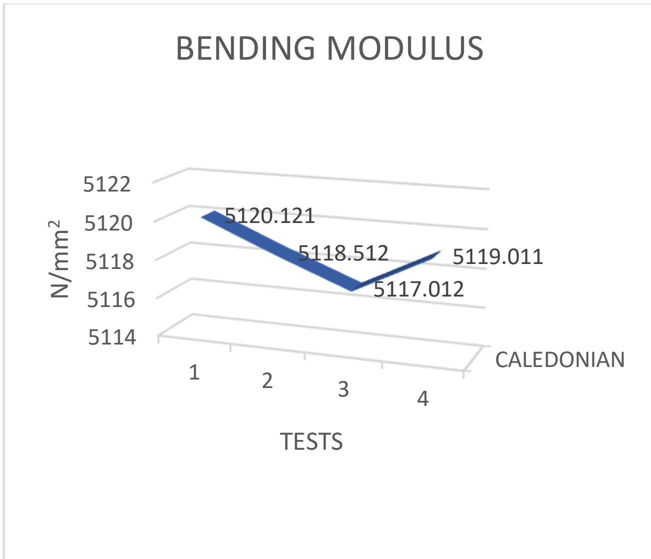

Figure 2: Bending modulus results for Caledonian

The figure 3 below is a chart for results for four tests conducted on Plywood EQ. The data generated did not show a lot of variation of the bending modulus of the sample, Plywood EQ.

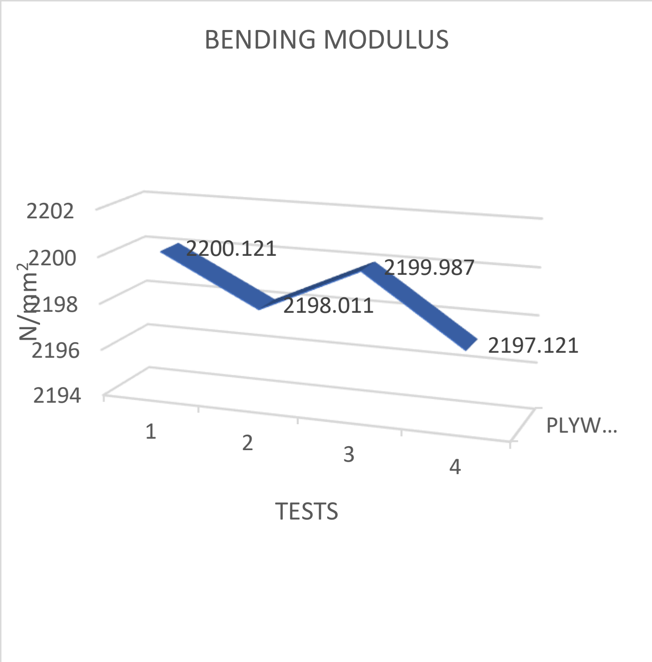

Figure 3: Bending modulus results for Plywood EQ

The figure 4 below is a chart for results for four tests conducted on Viewpoint. The data generated did not widely spread out showing clear trend of bending modulus of the sample, Viewpoint.

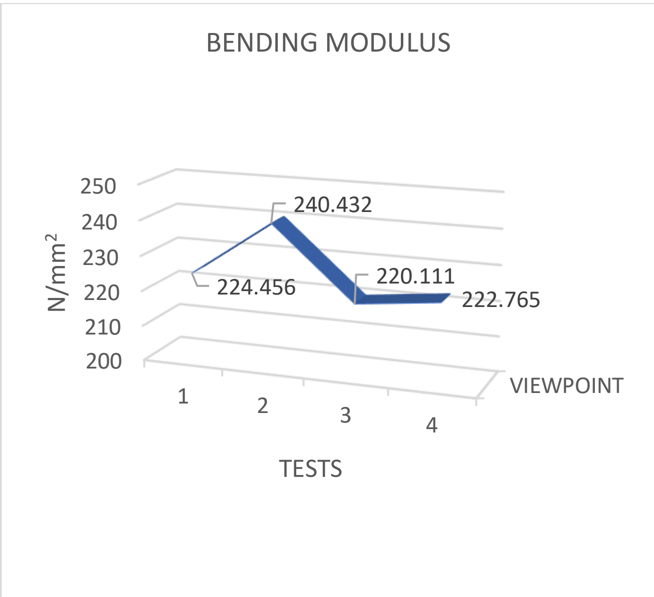

Figure 4: Bending modulus results for Viewpoint

The figure 5 below shows aggregate average for the four tests on Caledonian, Plywood EQ and Viewpoint. Bending modulus for Caledonian is 2919.854 N/mm^2 and 4891.723 N/mm^2 more than Plywood EQ and Viewpoint respectively. For Plywood EQ is 1971.869 N/mm^2 more than that of Viewpoint.

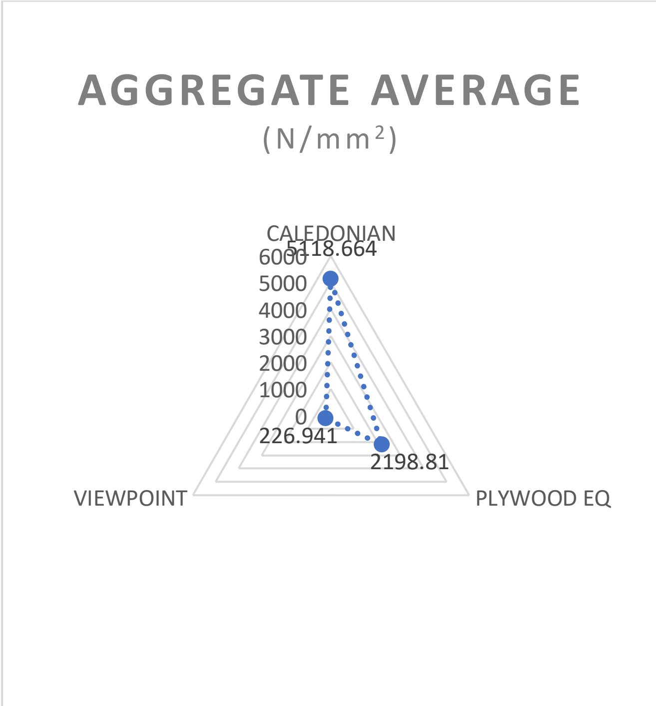

Figure 5: Bending modulus aggregate average results for Caledonian, Plywood EQ and Viewpoint

5. Conclusion and Recommendation

In a descending order of their bending modulus, Caledonian achieved aggregate average bending modulus test result of 5118.664 (N/mm^2), Plywood EQ attained aggregate average bending modulus test value of 2198.810 (N/mm^2) while in Viewpoint, aggregate average bending modulus test data was 226.941 (N/mm^2).

Comparatively, for veneered engineered wood (Plywood) in Nigerian market, bending modulus for Caledonian is 2919.854 N/mm^2 and 4891.723 N/mm^2 more than Plywood EQ and Viewpoint respectively. Bending modulus for Plywood EQ is 1971.869 N/mm^2 more than that of Viewpoint. From the tests, each sample showed some level of homogeneity, not varying widely as clearly revealed by aggregate average.

These values are very crucial in the choice of veneered engineered wood products with particular reference to their bending modulus. Recall that higher bending modulus for a material means more resistance to bending, that is increased rigidity, higher stress resistance, withstanding more force without deforming. So, depending on one's need for veneered engineered wood (Plywood) product in Nigeria, novel findings of this research stand out as a reference point for technical information needed in decision making regarding appropriate choice by engineers, contractors, policy makers and stake holders for sustainable development. Bending modulus research for other types engineered wood products commonly used should form future research interests.

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