



Bending Modulus Evaluation of Nigerian Market High Density Fibre Board (HDF) Engineered Wood for Sustainable Economy

Chimaobi Chinedu Okoye¹, Chukwudi Paulinus Ilo^{2*} & Valentine Ifeanyi Ozono³

^{1,2,3}Department of Mechanical and Production Engineering, Enugu State University of Science and Technology, P.M.B. 01660, Enugu, Nigeria

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ABSTRACT

Original Research Article

This paper investigated the bending modulus of three widely used high Density Fibre Board (HDF) engineered wood products in the Nigerian market Sinoply, Joubert and Dabar with the objective of providing technical guidance for material selection to support sustainable economic development. In accordance with ASTM D1037 and requirement with the testometric testing machine, a universal testing machine (UTM), four bending modulus tests were conducted per sample, and aggregate average values reported. Chats on the dynamics of the bending modulus of the samples were ensued by computer program from the data generated. The study compares the bending modulus of Sinoply, Joubert and Dabar, with ANOVA showing significant differences ($p < 0.001$) between all the three. Turkey's (HSD) post-hoc show differences with $p < 0.001$ for pairs Dabar and Joubert and Dabar and Sinoply while Turkey's (HSD) post-hoc result between Sinoply and Joubert show a significant difference with $p < 0.002$. Novelty of the research show that Dabar has the highest bending modulus of approximately 14282MPa, indicating the stiffest and best for applications needing strength and stiffness especially in structural uses. Joubert has lowest bending modulus of approximately 9862MPa as the most flexible is suited for applications requiring flexibility such as in curved designs while Sinoply is in between with approximately 10674MPa balancing strength and flexibility. Analytically, statistics show that the bending modulus for Dabar is 33.80% and 44.81% more optimal than that of Sinoply and Joubert respectively. Bending modulus for Sinoply is just 8.22% advantageous than that of Joubert. These findings imply varying suitability for applications requiring strength versus flexibility. The study concludes that Dabar exhibits the highest bending modulus, followed by Sinoply and Joubert, and recommends the application of these findings in engineering and construction practices as the sustainable novel technical knowledge as benchmark should be utilized in the designs, developments and constructions by biomedical, mechanical, civil engineers and construction companies. Bending modulus of other engineered wood products types yet to be researched should receive research attention in due course.

Keywords: Bending Resistance, Elasticity, Elongation, Flexure Strength, Mechanical Test, Resilience, Rigidity.

*Corresponding author: Chukwudi Paulinus Ilo

Department of Mechanical and Production Engineering, Enugu State University of Science and Technology, P.M.B. 01660, Enugu, Nigeria

Introduction

Background of the Study

Olorunnisola, (2023) Noted that wood processing for exportation and domestic consumption played a vital role in

the Nigerian economy from the late 1700s transversing 1960s usually referred to as the golden age of Nigerian forestry up till early 1970s. Ogunwusi (2012) also asserted that forestry products industrial goods exports were relished by Nigeria in the 1950's, 1960's and 1970's. FMRL, (2025) noted that

Nigerian engineered wood market was valued at USD 8.81 billion in 2023 is actually expected to reach USD 11.05 billion by 2030 growing at a CAGR of 3.3%. Shirsath, (2025) noted that global engineered wood market will reach USD 282.728 billion by the end of 2025 growing at a compound annual growth rate (CAGR) estimate of as much as 5.448% during 2025 with projection to reach USD 432.191 billion by the year 2033. Engineered wood products, a derivative of wood product are typically obtained through the processes of binding fibers, particles, the strands, or boards of wood together. Wood composite in Nigeria remains a vital engineered wood product used comprehensively across packaging industries, furniture and construction. Unfortunately, Nigeria as at present despite abundant raw materials and a fast-growing domestic market, mostly remain heavily dependent on engineered wood imports. Garcia-Garcia, Quiles-Carrilo, Montanes, Fombuena, and Balart (2018) Asserted that 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. Fasasi, Baba & Ogunmilua, (2024) noted that engineered wood products offer improved dimensional stability, mechanical properties as well as durability that streamline improved energy performance and larger complex structural elements. Garcia-Garcia, et al, (2018) stated that mechanical properties improvements are 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. In support of optimal processing conditions, comparable engineered wood products are made from vegetable fibers using lignin-containing materials as well as chemical additives to enable the integration of polymer and wood flour. The use of wood waste materials in the production of engineered wood products has climaxed the reduction in the need to fell old-growth forests.

There are unavoidable challenges associated with the use of engineered wood products. When exposed to moisture, humidity-induced warping which is not common in solid woods is a common experience in engineered wood product that are fiber-based and particle-based. Toxic formaldehyde from the finished products, a strong apprehension with engineered wood product is formed and generally appears when cheap and commonly used resins in the engineered wood product are usually made with urea-formaldehyde bonded products. Greater higher risk exists as a result of higher chemical heat content and melting properties when a comparison is made between engineered wood product and solid wood products. Igboekulie, Monye and Joseph (2022) in the study of effect of building materials cost on housing

development in Owerri, Imo state, eastern region of Nigeria noted that a significant association exists between rate of residential development and building materials prices while studying the effect of building materials cost on housing development in Owerri, Imo state, eastern region of Nigeria. Correlation analysis of the inflation rate and the prices of building materials in Benin city showed that inflation rate in Nigeria has a direct relationship with prices of building materials as inflation was the most influential factor responsible for increase in cost of building materials, (Obaedo, 2024). Barguma, et al, (2022) demonstrated 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 from the critical study of inflation trend pattern and its impact on Nigeria's economy. Demand for engineered wood product across the globe and especially within Nigeria as projected by earlier statistics is on the increase due to remarkable improvement on the esthetic and mechanical properties despite these impediments. Highlighting on sustainable economic development, it becomes indispensable to study the bending modulus of high density fibre board (HDF) engineered wood products in Nigeria as the specialized knowledge provided will significantly help to prevent associated financial loss due to use of inappropriate quality for multiple purposes.

Bending Modulus

It is important to understand the bending modulus of engineered wood composites, for example fiber-reinforced panels, cellular beams or medium density fibre board (MDF) engineered wood products because it is pivotal for validating their structural performance and comparing them to traditional materials like glulam or solid wood. Bending modulus is fundamental to ensuring the safety, serviceability, and performance of structures built with these materials. The bending modulus (or modulus of elasticity in bending) a critical engineering parameter for materials, directly quantifies the resistance to deflection under load and material's stiffness. Measuring a materials resistance to flexure of bending, bending modulus shows how stiff or rigid a material is when bent. Typically calculated from the ratio of stress to strain in bending, indicating stiffness. Exact 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.

Review of Literature

Aziz, et al, (2015) while studying the influence of activated carbon filler on the mechanical properties of wood composites, noted that MDF composites samples show higher strength value than plywood composites samples because of the increasing thickness of the activated carbon filler. In assessment of Medium Density Fibreboard (MDF) engineered wood load strain in Nigeria, (Ilo, Okoye, &

Ugama 2025) found that statistically, MDF Hokusan ability to elongate at break is 35.9526% and 57.8750% higher than that of Richard Russel and SKG Nordic respectively, placing MDF Hokusan favoured while Richard Russel elongation potential over SKG Nordic is just 16.1250%. Ilo, Nwanjoku and Olayeye (2025) studied flexural strength of medium density fibreboard (MDF) wood composite in Nigerian market and found that SGK Nordic had the best ultimate flexural strength of 13.568 N/mm², MDF Hokusan (MDF) recorded 1.24 N/mm², while Richard Russel had ultimate flexural strength of 12.986 N/mm². Ojo and Idieunmah, (2021) in an attempt to find the relationship between age and properties of timber, established linear relationship between age and strength properties of timber, increasing both the compression and shear strengths and even to a reasonable extent the bending strength. Okoye, Ilo, and Obuka, (2026) compares the bending modulus of MDF Hokusan, SGK Nordic and Richard Russel, the top most used medium density fibre board in Nigeria, with ANOVA showing highly significant differences ($p < 0.0001$) between all the three as well as Turkey's post-hoc showing differences with $p < 0.001$ for all pairs. Richard Russel exhibited the highest aggregate average bending modulus of 8697 MPa, indicating superior stiffness and strength. MDF Hokusan had the lowest with 1296 MPa, suggesting greater flexibility. SGK Nordic fell in-between with 7398 MPa. Flexural strength and elongation at break increased as coconut shell proportion got increased in the study of the effects of carbonized coconut shell (CS) volume fraction on mechanical properties of unsaturated polyester resin (UPR) composite and the mechanical properties by (Iloabachie, Obiorah, & Anene, 2018). Recently, (Ilo, Ajibo, & Dim 2025a) in Nigerian economy marine board assessment analysis, found that Marine Plex marine board plywood had ultimate bending strength of 17.96 N/mm², Nplex marine board plywood recorded 21.502 N/mm² while Super Plex marine board plywood had the best flexural strength at peak of 65.84 N/mm². In load strain evaluation of veneered engineered wood (plywood) in Nigerian market, (Ilo, Alumona, & Nwanjoku, 2025) from statistical analysis, showed that Viewpoint ability to elongate at break is 119.51% and 289.49% better than that of Caledonian and Plywood EQ respectively while Caledonian elongation at break potential over Plywood EQ is 78.32%. In the statistical analysis of wood load strain of high density fibre engineered wood product in Nigeria, (Ilo, Nwachi, & Chukwunyer, 2025) asserted 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 ability at break potential over Dabar is just 6.16% higher. 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 in the study of the evolution of surface properties of concrete through measured lightness and absorption by (Courard, et al, 2012). Ilo, Uro, and Edeh, (2025) found 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) in a hardness test analysis of veneered engineered wood (Plywood) in Nigerian market. In Nigerian economy marine board engineered wood load strain evaluation, (Ilo, Emenike, & Oshim, 2025) established that Super-Plex ability to elongate at break is 61.37% and 117.96% higher than that of Marine Plex and Nplex respectively while Marine Plex elongation at break potential over Nplex is 35.07%. Maximum flexural and ultimate tensile strength were attained at 20wt% 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, (Iloabachie, et al, (2017). Okoye, Ilo, and Kanu (2025) asserted that statistically, the bending modulus for Marine Plex is just 19.60% and as much as 163.66% better suited than that of Super-Plex and Nplex respectively while for Super-Plex, it is as much as 120.45% favourable than that of Nplex in appraisal of marine board engineered wood products in Nigerian market. 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 evaluation of marine board in Nigerian economy according to (Ilo, Nweke & Nebo, 2025). In hardness test analysis of medium density fibreboards MDF in Nigerian economy, (Eze, Ilo, & Dim, 2025a) found that 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. Akinyemi, Afolayan, and Oluwatobi 2016) found that panels with 50% CC had the most preferred performances for both physical and mechanical properties in a study of 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. Ilo, Ajibo, and Dim (2025b) found in experimental investigation of flexural strength of veneered engineered wood (Plywood) in Nigerian commercial sector that Viewpoint plywood recorded 4.956 N/mm², Plywood EQ recorded 9.467 N/mm² while Caledonian recorded 16.973 N/mm² as the maximum stress, modulus of rupture (MOR) each of them can withstand while being bent before failing or rupturing. Okoye, Ilo, and Chikelu, (2025) appraised the veneered engineered wood (Plywood) product in Nigerian economy bending modulus and found that statistically, 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 while bending modulus for Plywood EQ is 868.89% more suitable than that of Viewpoint. Flexural strength values in glulam beams were found significantly higher than the

control (custom wood) especially in edgewise direction in the assessment of glued laminated beams made from local wood species bonded with phenol resorcinol formaldehyde, urea-formaldehyde adhesives and polyurethane, (Ekundayo, Arum, & Owoyemi, 2022). In a study of the flexural strength of high density fibreboard (HDF) engineered wood in Nigerian economy, (Ilo, Nneji, & Igede, 2025) discovered that Joubert (HDF) recorded 15.604 N/mm², Dabar (HDF) recorded 32.604 N/mm² while Sinoply (HDF) recorded 39.248 N/mm² of their flexural strength at peak. Eze, Ilo, and Dim (2025b), unearthed that Dabar reached aggregate average hardness of 526.50 Leeb Hardness Test (HLD), Sinoply reached aggregate average hardness of 547.50 HLD while Joubert reached aggregate average hardness of 548.50 HLD in the hardness examination on high density fibreboards in Nigerian economic sector. Coconut fibre reinforced HDPE had 28.6 mega pascal as optimum value for flexural strength in an analysis of 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, (Ihueze, Achike, & Okafor 2016). From above it is obvious, in summary the lack of studies as research gap that research has not been directed towards providing technical insight on high density fibre board (HDF) engineered wood products in Nigerian economy with regards to their bending modulus, hence the visible need for this research paper and for the research gap to be closed. Arising from the literature review, what is explicitly new beyond prior HDF studies is the study of bending modulus of high density fibre board (HDF) engineered wood products in Nigerian economy.

Research Methodology

Material

Three widely used high density fibre board (HDF) engineered wood products in Nigerian economy were selected to value their bending modulus capabilities. The samples were selected for test and subsequent analysis and they were Sinoply, Joubert and Dabar. They are represented accordingly in table 1.

Table 1: High Density Fibre Board (HDF) Engineered Wood Product Samples Tested

Sample	a	b	c
Make	Sinoply	Joubert	Dabar

Equipment

Test specimens were prepared in accordance with ASTM D1037 and requirement with the testometric testing machine. Static bending tests were carried out using three-point loading configuration with a span length of 225mm and loading (crosshead) rate of approximately $\approx 5.6\text{mm/min}$ ($\pm 50\%$). Tests were done at relative humidity of $65\% \pm 5\%$ and controlled lab with minimal vibrations. Omicrom MD Digital moisture meter was used to establish the samples moisture

content since it has a range of 5%-40% while HDF normally has moisture content range upper limit of 10%. Comparability of the samples with respect to moisture content was ascertained. Comparability of samples with respect to density was confirmed. Figure 1, a universal testing machine (UTM) the testometric testing machine was used in the test. According to the resistive tendencies of each sample as the jaw moves down bending modulus data of the sample tested were generated. According to the requirement by the testometric machine shown in figure 1, the samples were all tested on the machine one after the other after being prepared diligently. Bending modulus aggregate average statistics of four replicates conducted on each of the samples were generated. With computer program the dynamics of the bending modulus charts for the test are also 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. Analysis of Variance (ANOVA) was run on the data to check if samples differ significantly. A follow-up Post-Hoc test (Tukey's) compared the pairs of samples. The statistical analysis and the charts generated are analysed under results and analysis below.



Figure 1: Testometric machine (A universal testing machine)

Results and Analysis

For each of the samples Sinoply, Joubert and Dabar, the charts 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 Sinoply, Joubert and Dabar.

Plots

The figure 2 below is a chart for results for four tests conducted on Sinoply. The data generated were within a close range which is an indication of homogeneity of the sample, Sinoply.

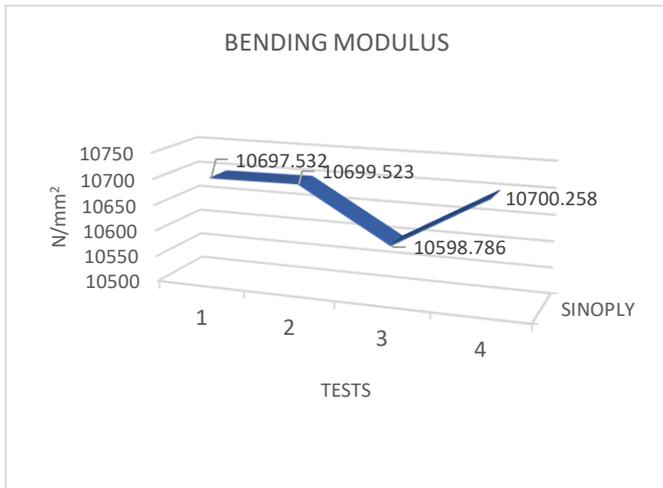


Figure 2: Bending modulus results for Sinoply

The figure 3 below is a chart for results for four tests conducted on Joubert. The data generated did not widely spread out showing clear trend of the bending modulus of the sample, Joubert.

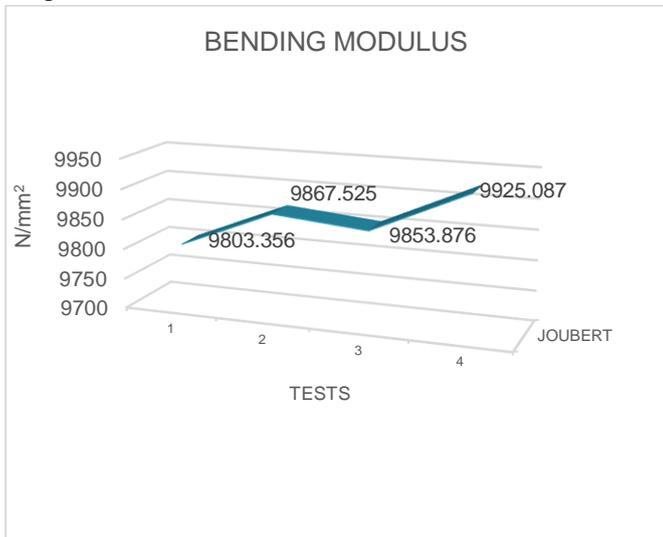


Figure 3: Bending modulus results for Joubert

The figure 4 below is a chart for results for four tests conducted on Dabar. The data generated was within the average range showing uniformity and clear trend of bending modulus of the sample, Dabar.

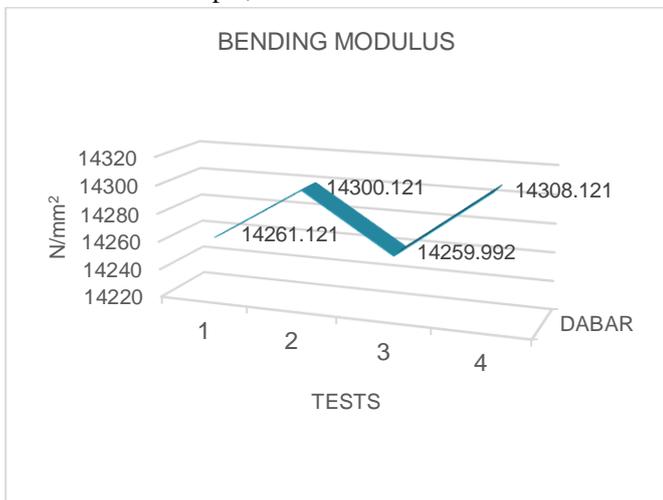


Figure 4: Bending modulus results for Dabar

The figure 5 below shows aggregate average for the four tests on Sinoply, Joubert and Dabar. From the ascending order of their bending modulus, the novelty of the research shows that Joubert achieved aggregate average bending modulus test result of 9862.46N/mm², Sinoply attained aggregate average bending modulus test value of 10674.02N/mm² while in Dabar, aggregate average bending modulus test data was 14282.34N/mm². Relatively, for high density fibre board (HDF) engineered wood products in Nigeria, bending modulus for Dabar is 3608.31N/mm² and 4419.88N/mm² more than Sinoply and Joubert respectively. Bending modulus of Sinoply is just 811.56N/mm² more than that of Joubert.

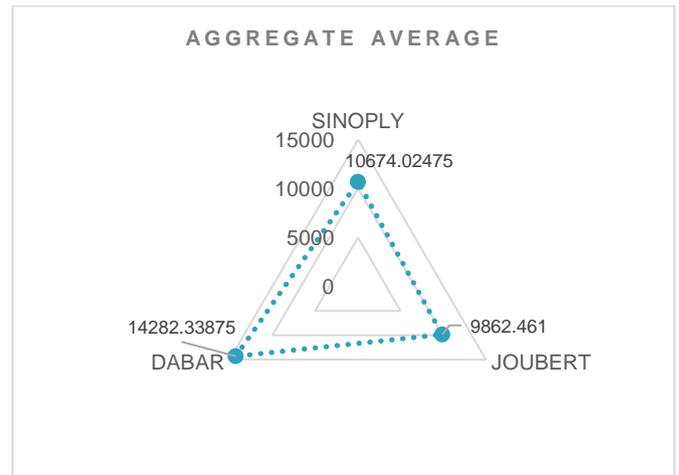


Figure 5: Bending modulus aggregate average results for Sinoply, Joubert and Dabar

Advanced statistical analysis of variance (ANOVA) result of $p < 0.001$ showed as insignificant difference between the samples. Turkey's (HSD) post-hoc result between Dabar and Joubert show a significant difference with $p < 0.001$. Turkey's (HSD) post-hoc result between Dabar and Sinoply show a significant difference with $p < 0.001$ while Turkey's (HSD) post-hoc result between Sinoply and Joubert show a significant difference with $p < 0.002$. All pairs differ significantly. Dabar has the highest modulus, Joubert lowest. As a measure of variability, error bar for Sinoply indicate $10,674.03 \pm 48.70$ MPa ($n=4$) with an error bar range of 10,625.33 MPa-10,722.73 MPa. Joubert indicate $9,862.46 \pm 49.57$ MPa ($n=4$) with an error bar range of 9,812.89 MPa-9,912.03 MPa. Dabar indicate $14,282.34 \pm 24.93$ MPa ($n=4$) with an error bar range of 14,257.41 MPa-14,307.27 MPa. This shows that Dabar has best consistency with highest stiffness and lowest variability, Joubert shows lowest stiffness and Sinoply has moderate stiffness with consistence performance.

Conclusion and Recommendation

From the tests, each sample showed some level of consistency, not varying greatly as clearly revealed by aggregate average even though bending modulus differ significantly between all three types. Novelty of the research show that Dabar has the highest bending modulus of

approximately 14282MPa, indicating the stiffest and best for applications needing strength and stiffness especially in structural uses. Joubert has lowest bending modulus of approximately 9862MPa as the most flexible is suited for applications requiring flexibility for example in curved designs while Sinoply is in between with approximately 10674MPa balancing strength and flexibility. Recall that higher bending modulus means stiffer and stronger board hence choice of type of HDF should be based on stiffness versus flexibility value. Joubert low value might mean it's designed for flexibility while Dabar's high value suggests it's desirability for high strength and stiffness hence load bearing ability.

Attaining sustainable economic development through prevention of loss associated with use of inadequate high density fibre board (HDF) engineered wood products in Nigeria, these values are very important in the choice of the products samples in Nigeria with particular reference to their bending modulus. With reference to one's need for high density fibre board (HDF) engineered wood products in Nigeria, its avant-garde stands out as a touchstone for technical insight needed in decision making regarding appropriate choice by engineers, contractors, policy makers and stake holders for sustainable development. Other types of engineered wood products commonly used in Nigeria economy not yet researched with respect to their bending modulus should form future research interest.

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