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Nigerian Market High Density Fibre Board (HDF) Engineered Wood Energy to Break Appraisal for Sustainable Economy

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ABSTRACT **Original Research Article**

Energy to break of the three most used high Density Fibre Board (HDF) engineered wood products in the Nigerian market Sinoply, Joubert and Dabar were investigated with the objective of providing technical guidance for material selection to support sustainable economic development. In accordance with ASTM D1037 standard and requirement with the testometric testing machine, a universal testing machine (UTM), four energies to break tests were conducted per sample, and aggregate average values reported. Plots on the dynamics of the energy to break of the samples were ensued by computer program from the data generated. Advanced statistical analysis of variance (ANOVA) result between groups, SS = 284.626, within groups SS =0.000597, F-statistic of F=5881.91 and p-value of $p<0.001$ showed a significant difference between the groups. Turkey's (HSD) post-hoc result between Sinoply and Joubert, Sinoply and Dabar and Joubert and Dabar show a significant difference with $p<0.001$ each respectively. All pairs differ significantly. Sinoply attained the highest energy to break of 10.88725N.m, as the toughest implying high impact resistant and most durable, Dabar is in-between with 0.67175N.m to balance toughness and brittleness while Joubert has energy to break of 0.588N.m as the most brittle best suited for applications where toughness is not much of a concern. These findings imply varying suitability for applications requiring toughness versus brittleness. This study concludes that Sinoply exhibits the highest energy to break, followed by Dabar 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. Other engineered wood products types yet to be researched should receive research attention in due course with regards to their energy to break.

Keywords: Fracture Energy, Mechanical Test, Resilience, Rigidity, Specific Energy Absorption, Toughness.

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Introduction

Background of the Study

Ogunwusi (2012) asserted that forestry products industrial goods exports were relished by Nigeria in the 1950's, 1960's and 1970's. Olorunnisola, (2023) also 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. At the global level, 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. In Nigeria, (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%. Wood composite in Nigeria remains a vital engineered wood product used comprehensively across packaging industries, furniture and construction. 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. Regrettably, as at present, Nigeria despite abundant raw materials and fast-growing domestic market remain heavily dependent on importation of engineered wood products. 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, 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. Garcia-Garcia, et al, (2018) again just like (Fasasi et al, 2024) noted 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. To support 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. Notably, usage of wood waste materials in the production of engineered wood products has pinnacle the reduction in the need to fell old-growth forests.

Some unavoidable challenges are associated with the use of engineered wood products. Humidity-induced warping usually not common in solid woods is a common experience in engineered wood product that are fiber-based and particle-based when exposed to moisture. 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. When a comparison is made between engineered wood product and solid wood products, greater higher risk usually exists as a result of higher chemical heat content and melting properties. It was demonstrated by (Barguma, et al, 2022) 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. Obaedo, (2024) in a 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. It was noted by (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. Due to remarkable improvement on the esthetic and mechanical properties despite these impediments, demand for engineered wood product across the globe and especially within Nigeria as projected by earlier statistics is on the increase. To maintain sustainable economic development, it becomes indispensable to study the energy to break 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 diverse applications.

Energy to Break

Energy to break refers to the amount of energy a material can absorb before it actually breaks, ruptures or fractures. It's a measure of material's toughness. Materials can absorb a lot of energy before breaking. For example, ductile metals have high energy to break. Brittle materials like glass have low energy to break. Energy to break also fracture energy as well as energy absorption capacity is usually obtained from tests on universal testing machines (UTM). The UTM measures the force applied and the displacement, allowing calculation of the energy absorbed which is the toughness up to the point of fracture. Materials with high energy to break values are generally more ductile and resistance to cracking while those with low values are more brittle.

Review of Literature

In an investigation by (Okoye, Ilo and Ozono, 2026) on the bending modulus of three widely used high Density Fibre Board (HDF) engineered wood products in the Nigerian market with the objective of providing technical guidance for material selection to support sustainable economic development, the research show that Dabar has the highest bending modulus of approximately 14282 MPa, indicating the stiffest and best for applications needing strength and stiffness especially in structural uses, Joubert has lowest bending modulus of approximately 9862 MPa as the most flexible is suited for applications requiring flexibility such as in curved designs while Sinoply is in between with approximately 10674 MPa balancing strength and flexibility. 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). 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/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 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%. 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, 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/mm^2, MDF Hokusan (MDF) recorded 1.24 N/mm^2, while Richard Russel had ultimate flexural strength of 12.986 N/mm^2. 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. 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. 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%. Again, 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%. 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). 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 the statistical analysis of wood load strain of high density fibre engineered wood product in Nigeria, (Ilo, Nwachi, & Chukwunyere, 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. 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).

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/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. 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 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. 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). 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. 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). 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. 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/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. 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. 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. As a fall out from the reviewed literature, what is explicitly new beyond prior HDF studies is the study of energy to break of high density fibre board (HDF) engineered wood products in Nigerian market. In summary lack of studies on energy to break of HDF in Nigerian market is evident. As a research gap the visible need of providing technical insight on high density fibre board (HDF) engineered wood products in Nigerian economy with regards to their energy to break becomes imperative to be closed, hence this paper.

Research Methodology

Material

Three most used high density fibre board (HDF) engineered wood products in Nigerian economy were selected to value their energy absorption capacity. The samples were selected for test and subsequent analysis and they were Sinoply, Joubert and Dabar as represented accordingly in table 1.

Table 1: High Density Fibre Board (HDF) Engineered Wood Product Samples Tested for Energy to Break

Sample	A	B	C
Make	**Sinoply**	**Joubert**	**Dabar**

Equipment

In accordance with ASTM D1037 standard and requirement with the testometric testing machine the test specimens were prepared. Quasi-static tests were carried out using three-point loading configuration with a span length of 225mm and loading (crosshead) rate of approximately ≈ 5.6mm/min (±50%). Tests were done at relative humidity of 65% ± 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 about 10%. Comparability of the samples with respect to density and moisture content were ascertained. 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 energy to break 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. Energy to break aggregate average statistics of four replicates conducted on each of the samples were generated. With computer program the dynamics of the energy to break chats 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 or measure of potentials of the material's amount of energy to be absorbed before it breaks or fractures which actually is a measure of a materials toughness. 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 chats 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 chats for energy to break are shown as charts in figures 2, 3 and 4 respectively while figure 5 X rays the energy to break 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.

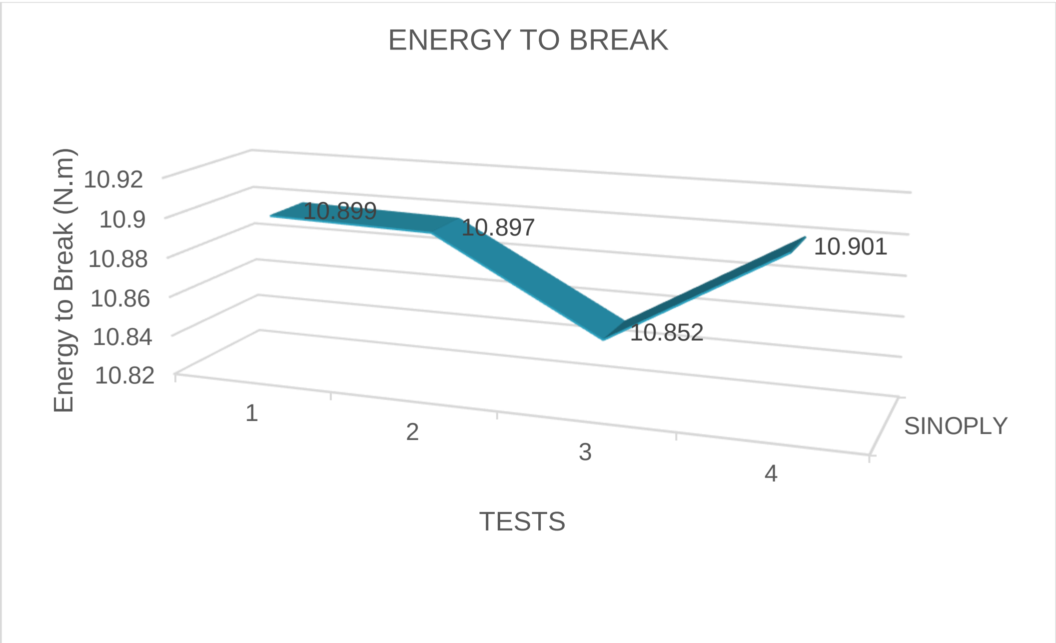

Figure 2: Energy to Break results for Sinoply

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 energy to break of the sample, Joubert.

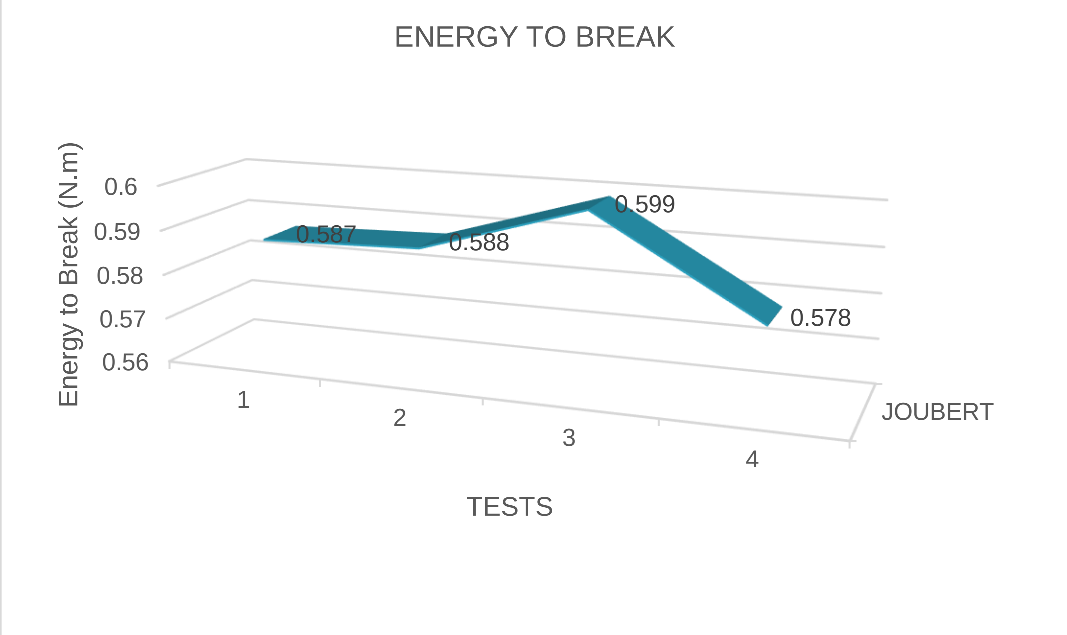

Figure 3: Energy to Break results for Joubert

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 energy to break of the sample, Dabar.

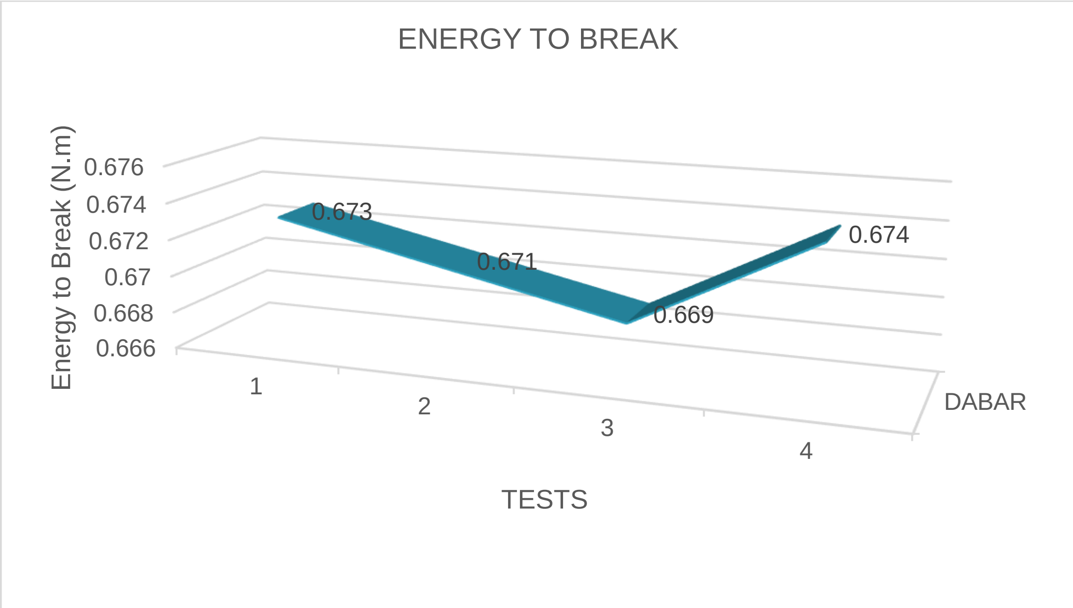

Figure 4: Energy to Break results for Dabar

The figure 5 below shows aggregate average for the four tests on Sinoply, Joubert and Dabar. From the ascending order of their energy to break, the novelty of the research shows that Joubert achieved aggregate average energy to break test result of 0.588 N.m, Dabar attained aggregate average energy to break test value of 0.67175 N.m while in Sinoply, aggregate average energy to break test data was 10.88725 N.m. Relatively, for high density fibre board (HDF) engineered wood products in Nigeria, energy to break for Sinoply is 10.21553 N.m and 10.29925 N.m more than Dabar and Joubert respectively. Energy to break for Dabar is just 0.08375 N.m more than that of Joubert.

Advanced statistical analysis of variance (ANOVA) result between groups, SS = 284.626, within groups SS =0.000597, F-statistic of F=5881.91 and p-value of $p<0.001$ showed a significant difference between the groups. Turkey's (HSD) post-hoc result between Sinoply and Joubert show a significant difference with $p<0.001$, Sinoply and Dabar show a significant difference with $p<0.001$ while Joubert and Dabar also show a significant difference with $p<0.001$. All pairs differ significantly.

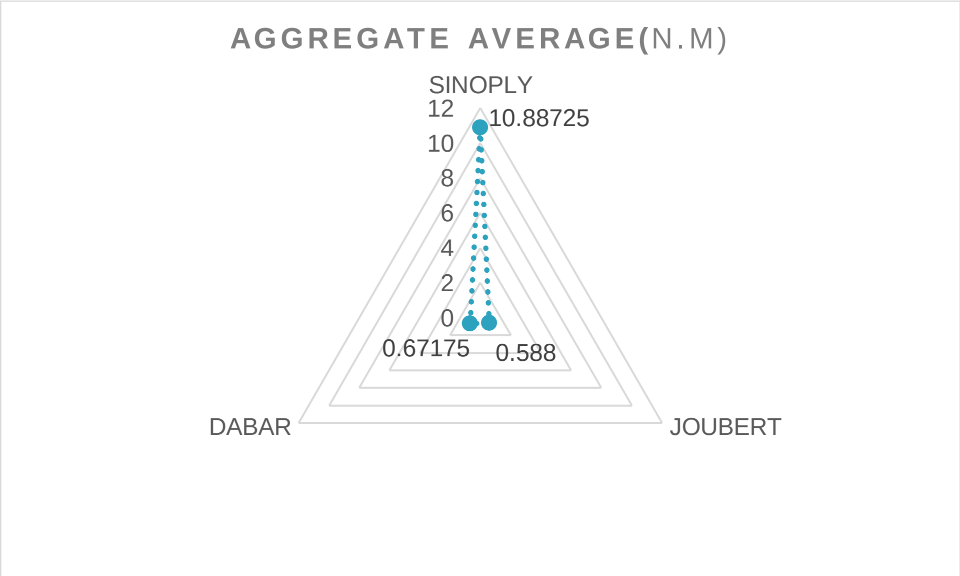

Figure 5: Energy to Break aggregate average results for Sinoply, Joubert and Dabar

Conclusion and Recommendation

Each sample showed some level of consistency, from the tests conducted. They did not vary greatly as clearly revealed by aggregate average even though energy to break differ significantly between all three types. The research novelty of show that Sinoply has the highest energy to break of approximately 10.88725 N.m, indicating the toughest and best for applications where impact resistant and durability matter most. Joubert has lowest energy to break of approximately 0.588 N.m as the most brittle is suited for applications where toughness matter least while Dabar is in between with approximately 0.67175 N.m balancing toughness and brittleness. Recall that higher energy to breakmeans tougher board hence choice of type of HDF should be based on toughness versus brittleness value. This shows that Sinoply can be utilsed in applications requiring high durability and resistance to breakage, Dabar offers a balance in performance while Dabar's application in non-load or low stress applications should be preferred.

These values are very important in the choice of the products samples in Nigeria market with particular reference to their energy to break for assurance of sustainable economic development through prevention of loss associated with use of indecorous high density fibre board (HDF) engineered wood products in Nigeria market. Concerning one's need for high density fibre board (HDF) engineered wood products in Nigeria, its trailblazing stands out as a benchmark for technical insight needed in decision making regarding appropriate choice by engineers, contractors, policy makers and stake holders for sustainable development. Future research interest should centre on other types of engineered wood products commonly used in Nigeria economy not yet researched with respect to their energy to break.

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