APPRAISAL OF NIGERIAN COMMERCIAL SECTOR HIGH DENSITY FIBREBOARD (HDF) ENGINEERED WOOD LOAD STRAIN

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Abstract: **As a result of non-availability of data to avert the usual loss of revenue due to failure associated with using inappropriate high-density fiberboard (HDF) engineered wood product samples in Nigerian market with respect to their strain and deformation at load, technical insights to prevent loss due to choice of indecorous quality for abundant needs was investigated. The three most sought after were identified, prepared and subjected to test as required by a universal testing machine (UTM), the testometric testing machine. Chats on Strain at Break (%) and Deformation at Break (mm) of the samples were ensued by computer program from the generated data. From statistical analysis, 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. Joubert elongation potential over Dabar is just 6.16%. Empirically also, dynamics of the deformation at break exhibited analogous pattern, where Sinoply ability to deform is 544.58% and 506.98% more than that of Dabar and Joubert respectively. Joubert deformation potential over Dabar is just 6.19%. This novel technical insight when leveraged on can prevent loss of revenue associated with such failures as it can be utilized by engineers, building contractors, construction companies as well as furniture makers. Biomedical and mechatronics engineers can as well tap on this knowledge. Future research in this area should be geared towards other engineered wood product.**

Keywords: **Bending Rigidity, Creep, Durability, Elasticity, Elongation, Extension, Flexural Modulus, Flexure Strength, Mechanical Test, Modulus of Rupture, Pull, Resilience, Stress, Tension.**

I. INTRODUCTION

Background of the Study

Wood composite in Nigeria remains a vital engineered wood product as it is extensively used across construction, furniture, and packaging industries. Despite abundant raw materials and a fast-growing domestic market, it is unfortunate that Nigeria presently remains heavily dependent on plywood imports. The global plywood market valued at USD 50.2 billion in 2024 is expected to grow from year 2025 with projection to reach USD 74.5 billion by the year 2033 at a compound annual growth rate (CAGR) estimate of 4.5% [1]. [1] noted that Nigerian plywood market valued at USD 8.81 billion in 2023 is expected to grow at a CAGR of 3.3%, reaching USD 11.05 billion by 2030. [2] observed that Nigeria once enjoyed forestry products industrial goods exports in the 1950's, 1960's and 1970's. Normally obtained through the processes of binding the particles, strands, boards, or fibers of wood together, wood composites, a derivative of wood product.

While helping facilitate optimal processing conditions, similar composite products can also be made from vegetable fibers using lignin-containing materials with chemical additives enabling the integration of polymer and wood flour. [3] observed that of highly environmentally-friendly fiberboards by hot-press molding using Posidonia oceanica wastes and a partially biobased epoxy resin as binder showed that there is a remarkable improvement of the mechanical properties with combination of the alkali treatment followed by silanization. [3] again noted that particle and fiberboards 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 thermal insulators, ceiling boards, wall partitions, e.t.c. due to an excellent combination of mechanical, thermal and acoustic properties together with a competitive price. Engineered to certain specifications resulting in a material that can have diverse applications, wood composites are achieved by the use adhesives. Wood composites can be created by the use of smaller trees, wood waste materials and hence it is of interest to note the reduction in the need to fell old-growth forests.

Notwithstanding these advantages when wood composite is compared to solid wood products, higher fire hazards could be experienced due to higher chemical heat content and melting properties of composites. Cheap and commonly used resins in the composites are usually made with urea-formaldehyde bonded products which usually release toxic formaldehyde from the finished products forming a strong apprehension with wood composite. Wood composites have numerous advantages as it relates to solid timber demands for extra primary energy in the process of their manufacture. When some fiber-based and particle based composite woods are exposed to moisture they experience humidity-induced warping which is not common in solid woods. As projected by the earlier statistics, despite all these challenges stated due to remarkable improvement on esthetic and mechanical properties of the resulting composites, the demand for wood composite is interestingly noted to be on the rise. In a revelation that the economy especially building materials market was badly hit by the inflation, the purchasing power of the Nigerian currency Naira in the study of inflation trend pattern and its impact on Nigeria's economy expectedly was seen to be decreasing [4]. [5] noted that a very strong relationship has been found to exist between building materials prices and rate of residential development when the effect of building materials cost on housing development in Owerri, Imo state, eastern region of Nigeria was assessed. According to [6] 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 prices of the building materials having a direct relationship with the inflation rate in Nigeria thus the cause for the high cost of building materials.

Strain in Materials Behaviour

Material properties are characteristics that define a material's behaviour under various conditions. In materials science, strain refers to the deformation or displacement of a material under stress, which is typically expressed as a ratio of the change in length to the original length in mm/mm usually expressed as a percentage (%). Materials respond to strain in different ways. Within elastic behaviour (elastic strain), reversible deformation is experienced, where materials can return to their original shapes after stress or force is removed. This common in rubber and steel for example. Clay and copper deform permanently under plastic behaviour (plastic strain). The materials do not return to their original shape after the force is removed. Again, materials like glass and ceramics fracture easily under brittle behaviour. Strain gauges are devices that detect changes in electrical resistance or capacitance which is as a result of deformation. Instruments like extensometers measure changes in length or displacement. Key concepts guide or describe materials behaviour. Linear relationship between stress and strain in elastic materials are described by Hooke's law. As an important concept, data and understanding of materials strain help in choice of materials in materials selection. Secondly, in structural analysis, strain analysis predicts material behaviour under various loads. Finally in failure prediction, excessive strain can lead to material failure.

II. REVIEW OF LITERATURE

[7] found that maximum flexural and ultimate tensile strength were attained at 20wt% for the 425 microns sample when the effect of particle size on the flexural strength, ultimate tensile 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. Flexural strength and elongation at break increased as coconut shell proportion got increased upon the study of the effects of carbonized coconut shell (CS) volume fraction on mechanical properties of unsaturated polyester resin (UPR) composite [8]. Coconut fibre reinforced HDPE has 28.6 mega pascal as optimum value for flexural strength when 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 was studied, [9]. Good interfacial adhesion between sawdust particle and LDPE reduced thickness swelling and improving moisture resistance by diminishing hygroscopy hence expanding the utilization of composites from agricultural wastes and plastic wastes for industrial applications, especially in moist environments, even as well as marine use and humid environment was also revealed by the study. Both physical and mechanical properties, the panels with 50% CC had the most preferred performances when the properties of developed composite corn cob (CC) and sawdust (SD) particle boards using 100%, 75%, 50%, 25% and 0% variations for both agricultural wastes using formaldehyde as binder at constant volume was studied [10]. [11] noted that changes were observed on surface quality after 50 reuses with oriented strand board (OSB) panels formworks while modification of surface quality was noticed after 80 reuses with marine plywood formworks when critical evolution of surface properties of concrete through measured lightness and absorption was analysed in the study of panel formworks. The values in glulam beams are significantly higher than the control (custom wood) especially in edgewise direction when assessment of the flexural strength of glued laminated beams made from local wood species bonded with phenol resorcinol formaldehyde, polyurethane and urea-formaldehyde adhesives was made [12].

In an attempt to find the relationship between age and properties of timber [13], 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. When the effect of adding a blend of tannins to commercial urea formaldehyde (UF) on the particleboard made from wood particles of Acacia seyal var. seyal using the British Standard European Norm (BSEN) relevant standards as compared to the ones produced by solely urea formaldehyde (UF) was investigated, high mechanical properties were found [14]. By simple methodology of just increasing the percentage of (CNSL), tensile strength of Teak Wood Saw Dust – Cashew nut shell liquid resin composites was studied by preparing a composite material using a hand layup technique by varying the quantity of the Cashew nut shell liquid (CNSL) resin and keeping the saw dust quantity constant. The tensile strength of the sample with the highest percentage of (CSNL) was seen to be the highest and that the tensile increased with increase in (CNSL), according to the ASTM D638, [15]. This reveals that the tensile strength of the composite is improved with the increase in the cashew nut shell liquid (CNSL) percentage. The tensile strength, face screw holding and modulus of rupture meet the minimum specifications of the US standards when both physical and mechanical properties of WPC evaluated in a study conducted to test for the potentials of low-density polyethylene (LDPE) such as plastic films from packaging as resins for saw dust from coconut lumber for the production of wood-plastic composite (WPC) particleboard when the boards were prepared from 50%-80% by weight of LPDE to sawdust content, [16]. Carbonized coconut shell particle reinforced composite recorded the least density value making it desirable in light weight material application when the effects of carbonization on the physical and mechanical properties of coconut shell particle reinforced polyester composite was studied, [17]. [18] showed that empty fruit bunch fibre reinforced polyester matrix composite has the maximum hardness strength of 19.062 N/mm^2 which depended greatly on the reinforcement combinations of control factors upon the optimization of hardness strengths response of plantain fibres reinforced polyester matrix composites (PFRP) by application of Taguchi robust design. [19] revealed that wear behaviours of 9500C carbonized ash were better than those of 8500C and 9000C carbonized ash due to the degree of alteration in the structure of silica upon the analysis of the effect of carbonization temperature on wear rate behaviour of rice husk ash reinforced epoxy composites. SGK Nordic had the best ultimate flexural strength of 13.568 N/mm2, Richard Russel had ultimate flexural strength of 12.986 N/mm2 while MDF Hokusan (MDF) recorded 1.24 N/mm2 as noted by [20] in a study of flexural strength of medium density fibreboard (MDF) wood composite in Nigerian market. [21] in a hardness test analysis of plywood, results show that Caledonian attained aggregate average hardness of 407.5 Leeds Hardness Test (HLD), View Point attained aggregate average hardness of 456.5 HLD while Plywood EQ attained aggregate average hardness of 459.25 HLD. [22] in a hardness test analysis of marine board, results show that Marine Plex attained aggregate average hardness of 364.5 Leeds Hardness Test (HLD), Super-Plex attained aggregate average hardness of 370.75 HLD while Nplex attained aggregate average hardness of 392.25 HLD. While the study was conducted on the influence of activated carbon filler on the mechanical properties of wood composites, higher strength value of medium density fibreboards (MDF) composites samples than plywood composites samples was revealed because of the increasing thickness of the activated carbon filler, [23]. [24] hardness test analysis of medium density fibreboards MDF in Nigerian market, Hokusan attained aggregate average hardness of 535.75 Leeds Hardness Test (HLD), Richard Russel attained aggregate average hardness of 545.75 HLD while SGK Nordiac attained aggregate average hardness of 558.50 HLD. [25] also conducted hardness test on marine boards and results show that Dabar attained aggregate average hardness of 526.50 Leeds Hardness Test (HLD), Joubert attained aggregate average hardness of 548.50 HLD while Sinoply attained aggregate average hardness of 547.50 HLD.

In summary, it is obvious that research has not been directed towards providing technical information on high density fibreboards (HDF) in Nigerian market with regards to load strain analysis from the review of related literature, hence the obvious need for this research paper.

III. RESEARCH METHODOLOGY

Material

Research was made in Nigerian market on commonly used and major high density fibreboard (HDF) engineered wood product samples in the Nigerian market for tests to appraise their maximum strain potentials. From the survey made, most common and three major high density fibreboard (HDF) in top demands in Nigerian market were identified. They were selected as samples for analysis. The high-density fiberboard (HDF) engineered wood product samples were Sinoply, Joubert and Dabar. They are represented accordingly in table 1.

In table 1, the samples are marked "a", "b" and "c" representing Joubert, Sinoply and Dabar respectively. They are all prepared according to the requirement by the machine and tested on the machine one after the other.

TABLE 1: High-Density Fiberboard (HDF) engineered wood product samples tested

Sample	a	b	c
Make	Joubert	Sinoply	Dabar

Equipment

A universal testing machine (UTM) the testometric testing machine shown in figure 1 was use in the test. It works by clamping down on a sample of high-density fibreboard (HDF) engineered wood product appropriately conditioned as required by the machine and mounted on it for test. As the jaw moves down, by the resistive potentials of each sample, data on the properties of the material including Strain at Break (%) and Deformation at Break (mm) were generated.

Prepared diligently according to the requirement by the testometric machine shown in figure 1, the samples (a) representing Joubert, (b) representing Sinoply and (c) representing Dabar were all tested on the machine one after the other. 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 high-density fibreboard (HDF) engineered wood product samples, Strain at Break (%) and Deformation at Break (mm) data of the high-density fibreboard (HDF) engineered wood product samples are evaluated during the process. With computer program the dynamics of the Strain at Break (%) and Deformation at Break (mm) plots for the test are generated from data obtained. Obviously, the plot being a function of the samples compositions resulting from their nature is a clear indication of the change in length to the original length in a material under load. In this case the material being the high-density fibreboard (HDF) engineered wood product samples. The data generated is analysed under results and analysis below.

Fig. 1: Testometric machine

IV.   RESULTS AND ANALYSIS

For each of the samples Joubert, Sinoply and Dabar, the plots for Strain at Break (%), Deformation at Break (mm) and combined dynamics of the Strain and Deformation are shown as charts in figures 2, 3 and 4 respectively.

Plots

The figure 2 below is a chart for Strain at Break (%) for the samples Joubert, Sinoply and Dabar. Dabar attained 0.519% strain at break, Joubert attained 0.551% strain at break while Sinoply attained 3.347% strain at break.
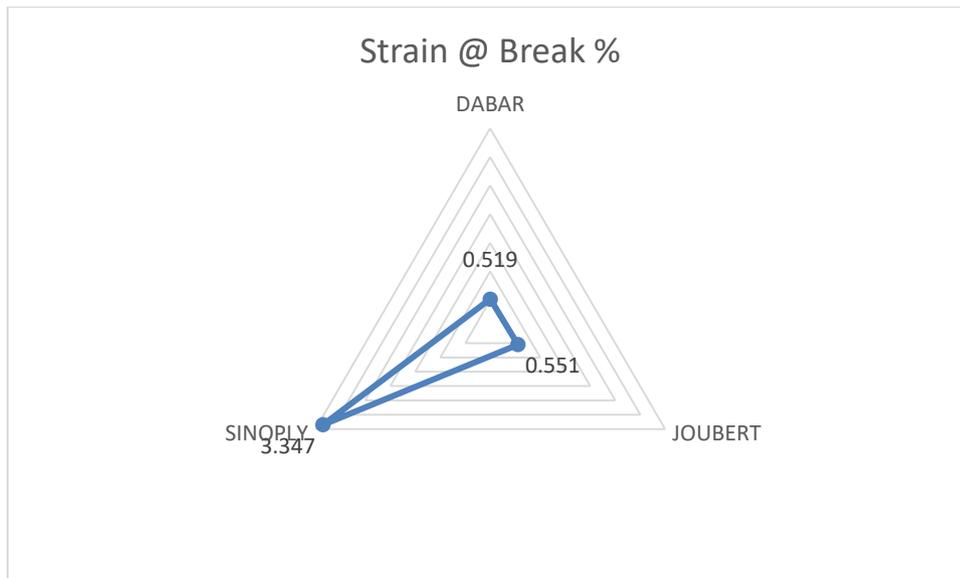

Fig 2: Chart of Strain at Break (%) for the samples Joubert, Sinoply and Dabar.

The figure 3 below is a chart for Deformation at Break (mm) for the samples Joubert, Sinoply and Dabar. Dabar recorded 2.308mm deformation at break, Joubert recorded 2.451mm deformation at break while Sinoply recorded 14.877mm deformation at break.
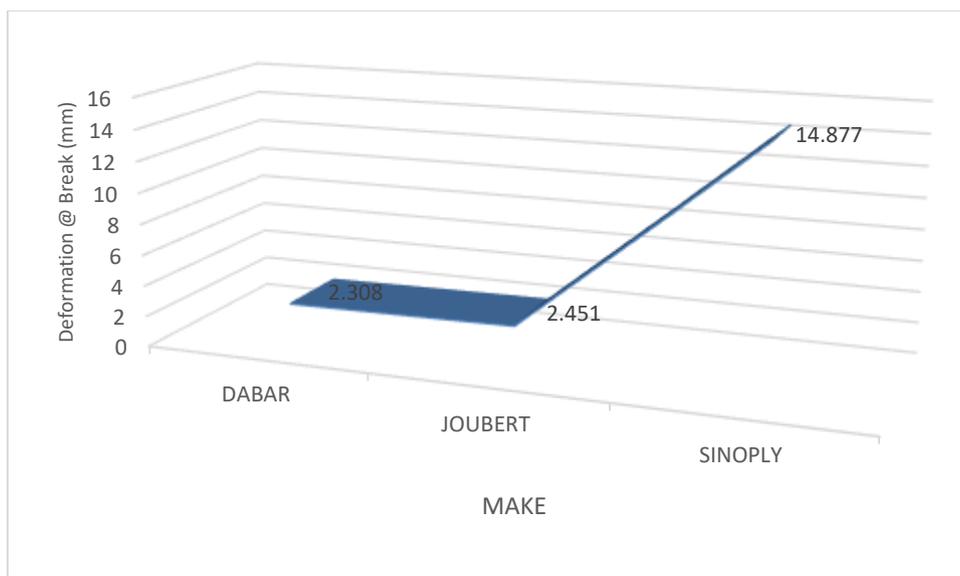

Fig. 3: Chart of Deformation at Break (mm) for the samples Joubert, Sinoply and Dabar.

The figure 4 below is a chart for relationship between Strain at Break (%) and Deformation at Break (mm) for the samples Joubert, Sinoply and Dabar. A direct relationship is established between the strain and deformation for the samples Joubert, Sinoply and Dabar with series 1 being strain while series 2 being the deformation.
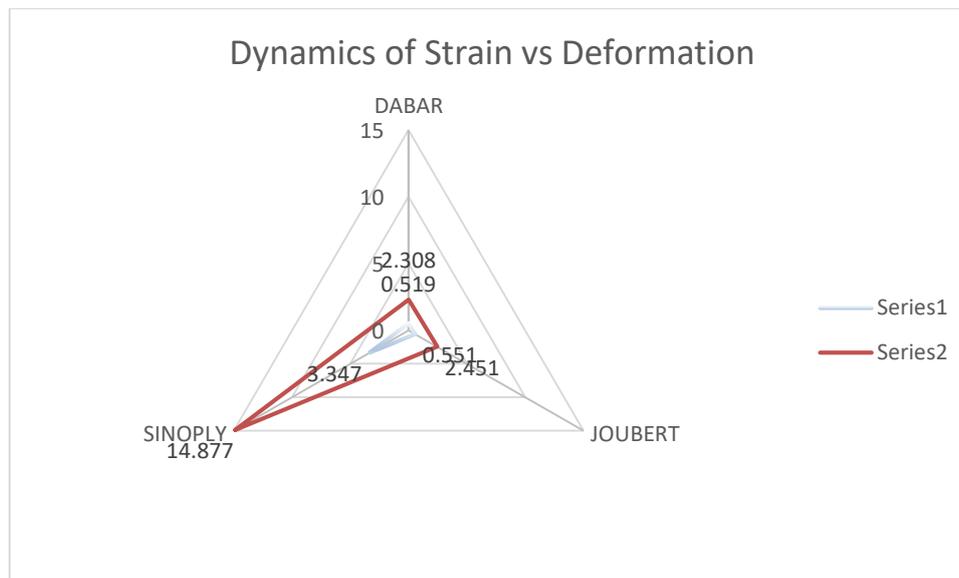
Fig. 4: Chart of Strain at Break (%) and Deformation at Break (mm) for the samples Joubert, Sinoply and Dabar.

V.   CONCLUSION AND RECOMMENDATION

In an ascending order of their Strain at Break (%) for the samples Joubert, Sinoply and Dabar, Dabar achieved strain at break of 0.519%, Joubert achieved strain at break of 0.551% while Sinoply achieved strain at break of 3.347%. From statistical analysis, Sinoply ability to elongate is 544.89% and 507.44.89% more than that of Dabar and Joubert respectively. Joubert elongation potential over Dabar is just 6.16%. Again, in an ascending order of their Deformation at Break (%) for the samples Joubert, Sinoply and Dabar, Dabar attained deformation at break of 2.308mm, Joubert attained deformation at break of 2.451mm while Sinoply attained deformation at break of 14.877mm. Empirically also, dynamics of the deformation at break exhibited analogous pattern, where Sinoply ability to deformate is 544.58% and 506.98% more than that of Dabar and Joubert respectively. Joubert deformation potential over Dabar is just 6.19%. This Novel technical insight on strain and deformation abilities of high-density fibreboard (HDF) engineered wood product should be valued by architects, building contractors, engineers, individuals, construction companies as well as furniture makers. Biomedical as well as mechatronics equipment developers can as well utilise this knowledge. Strain and deformation investigation of other engineered wood products should form future research works.

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