

# ANALYSIS OF FLEXURAL STRENGTH OF WOOD COMPOSITE (PLYWOOD) IN NIGERIAN COMMERCIAL SECTOR

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**Abstract:** To avert the usual loss of revenue due to failure associated with using different inappropriate composite (plywood) makes for various needs as a result of unavailability of requisite technical data, analysis of flexural strength of wood composites (plywoods) in Nigerian markets was conducted. Three most common makes in the market and most frequently purchased were identified and subjected to test to ascertain the bending strength at peak or their modulus of rupture (MOR). The materials were conditioned as required by the testometric machine (a universal testing machine) and tested. Data were generated and dynamics of stress-strain curve obtained from computer program. Results indicate that, Caledonian recorded 16.973 N/mm<sup>2</sup>, Plywood EQ recorded 9.467 N/mm<sup>2</sup> and Viewpoint recorded 4.956 N/mm<sup>2</sup> as the maximum stress each of them can withstand while being bent before failing or rupturing. This means that plywood Caledonian which recorded the highest bending strength at peak of 16.973 N/mm<sup>2</sup> is the best in Nigerian market in terms of bending strength tolerance. Depending on the need for plywood with regards to MOR, especially those in the construction industry, choice on the make of plywood should refer to result of this research. If the result of this paper is effectively utilized and applied especially in the construction sector it would prevent the frequent collapse of building under construction shortly after casting of beams even before setting is attained which is usually attributed to bending strength at peak of materials used for casting of beams, hence precluding loss of revenue.

**Keywords:** Bending Rigidity, Creep, Durability, Elasticity, Flexural Modulus, Flexure Strength, Mechanical Test, Modulus of Rupture, Resilience.

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## I. INTRODUCTION

### BACKGROUND OF THE STUDY

Nigeria once enjoyed export of forestry products industrial goods in the 1950's, 1960's and 1970's, [1]. Extensively used across construction, furniture, and packaging industries in Nigeria, plywood remains a vital engineered wood product. Unfortunately, Nigeria presently remains heavily dependent on plywood imports, despite abundant raw materials and a fast-growing domestic market. Expected to grow at a CAGR of 3.3%, reaching USD 11.05 billion by 2030, the Nigerian plywood market valued at USD 8.81 billion in 2023 is on a growth direction, [2].

Composite wood products can be used in a variety of different ways, including both home and industrial construction, and is often used to replace steel for joists and beams in building projects. Their most widespread use, however, is in outdoor deck flooring, but they are also popular for railings, fencing, benches, window and door frames, cladding and landscaping work.

While composite wood can be used in most applications traditionally using solid wood, it is also a popular material for making flat-pack furniture due to its low manufacturing costs and light weight properties.

Plywood is considered the original composite wood product, manufactured from sheets of cross-laminated veneer which are bonded with moisture-resistant adhesives under heat. Fiberboard is another, made by combining wood fibers with wax and a resin binder under high temperatures and pressure, while particle board is manufactured from wood chips or sawmill shavings pressed with a synthetic resin. Composite wood is also easy to work with using regular tools and can be efficiently cut, fastened and drilled using basic skills. It is easily malleable and can be molded into almost any desired shape. Plywood, for example, can be easily bent to create a curved surface, without compromising its strength. It can also be manufactured into large panel sizes meaning that builders don't have to install numerous smaller pieces.

Plywood as a typical form of composite material is made from multiple layers of wood veneer, adhesives bonding the layers together and the layers are typically oriented at right angles to each other, enhancing strength and stability. As a composite, plywood offers advantages like improved strength, dimensional stability and resistance to warping. Plywood's composite structure makes it suitable for various applications, including construction, furniture making and cabinetry amongst other uses. Its layered composition provides unique benefits compared to solid wood.

Plywood is classified based on various factors, including grade, that is including A, B, C, D (based on appearance and quality), grade A being highest quality with smooth surface and grade D lower quality and may have defects, type such as softwood plywood (e.g., pine, spruce), hardwood plywood (e.g., birch, oak), tropical plywood (e.g., from tropical hardwoods), core type, example veneer core, lumber core, composite core, application like structural plywood (for building and construction), non-structural plywood (for furniture, decorative purposes), moisture Resistance, exterior plywood (water-resistant glue), interior plywood (standard glue), thickness, various thicknesses, often measured in millimeters or inches. These classifications help determine the suitability of plywood for specific projects and applications. Plywood characteristics include layered structure, strong and durable and can be used for structural applications.

Despite its environmental advantages, some wood composites do require more primary energy for their manufacture when compared to solid lumber. Some particle and fiber-based composite woods are also not suitable for outdoor use as they can absorb water and be more prone to humidity-induced warping than solid woods. Another concern regarding wood composites is the adhesives used in their design with some resins releasing toxic formaldehyde in the finished product (particularly those made with urea-formaldehyde bonded products which is one of the cheapest and most common adhesives). The plastic materials often used in the creation of wood composites also have a higher fire hazard when compared to solid wood products, due to their higher chemical heat content and melting properties.

[3] studied the inflation trend pattern and its impact on Nigeria's economy and found that the purchasing power of the Nigeria currency, Naira, was seen to be decreasing, which revealed that the inflation is really affecting the economy. [4] while analyzing the inflation rate and the prices of building materials in Benin city observed that correlation analysis indicated that the prices of the building materials had a direct relationship with the inflation rate in Nigeria thus the cause for the high cost of building materials. [5] in their quest to assess of the effect of building materials cost on housing development in Owerri, Imo State, Nigeria, revealed inflation as the most influential factor responsible for increase in the cost of building materials and secondly, a very strong relationship exists between building materials prices and rate of residential development. With the foregoing, it is obvious that effort should be geared towards conserving resources by buying right construction material especially with current predicted inflation in Nigerian economy. This could be achieved by providing prospective buyers with some relevant technical data on building materials (plywood inclusive) in Nigeria market relating to standard and quality.

### **BENDING STRENGTH AT PEAK**

Flexural strength is a measure of a material's ability to withstand bending forces without breaking or deforming excessively and is calculated by applying a load to a sample of the material until it fails. It's typically measured in units of stress, such as: pascals (Pa), megapascals (MPa), pounds per square inch (psi) or Newton per square meter in system international unit, SI. Bending strength at peak, also known as peak bending strength or modulus of rupture (MOR), refers to the maximum stress a material can withstand while being bent before failing or rupturing. Bending strength at peak is crucial in designing and evaluating materials like concrete, composites (plywood), ceramics e.t.c. for various engineering applications where bending loads are significant, like: beams, bridges or structural components.

II. LITERATURE REVIEW

[6] while analyzing the effect of carbonized temperature on wear rate behaviour of rice husk ash reinforced epoxy composites observed 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. [7] observed that carbonized coconut shell particle reinforced composite recorded the least density value making it desirable in light weight material application from the study of effects of carbonization on the physical and mechanical properties of coconut shell particle reinforced polyester composite. [8] while studying the optimization of hardness strengths response of plantain fibers reinforced polyester matrix composites (PFRP) by applying Taguchi robust design observed that empty fruit bunch fiber reinforced polyester matrix composite has the maximum hardness strength of 19.062 N/mm<sup>2</sup> which depended greatly on the reinforcement combinations of control factors. [9] while studying the optimal performance characteristics and reinforcement combinations of coconut fiber reinforced high density polyethylene (HDPE) polymer matrixes at optimum condition of volume fractions and particle sizes of coconut fiber-filler observed that coconut fiber reinforced HDPE has 28.6 mega pascal as optimum value for flexural strength. [10] 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. [11] 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. [12] studied the production of highly environmentally-friendly fiberboards by hot-press moulding using Posidonia oceanica wastes and a partially biobased epoxy resin as binder. The resulting fiberboards represent a formaldehyde-free solution and can positively contribute to sustainable development as the lignocellulosic component is a waste and the binder resin is partially biobased. Worthy of note is that the reviewed works were not centered on providing technical information on the different makes of plywood in Nigerian market.

III. METHODOLOGY

MATERIAL

Three major and most common plywood were identified in Nigerian market from the survey made. They were selected as samples for analysis. The plywoods were Caledonian, EQ and Viewpoint as evident in the figure 1 as well as table I.

TABLE: I Plywood Samples tested

Sample	a	b	C
Make	Caledonian	EQ	Viewpoint

In figure 1, the samples are as shown below and marked “a”, “b” and “c” representing Caledonian, EQ and Viewpoint respectively.

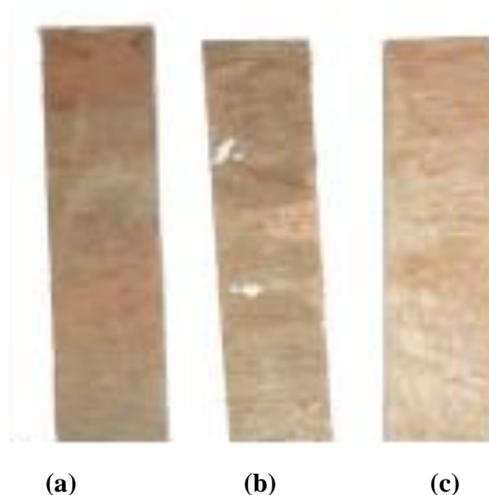


Fig. 1 Plywood samples

The samples (a) representing Caledonian, (b) representing EQ and (c) representing Viewpoint were all prepared according to the requirement by the machine and tested on the machine one after the other. The materials were conditioned as required by the testometric machine by cutting to the dimensions of 30mm x 200mm so as to fit in with the testing machine. The flexural test was carried out using TESTOMETRIC MACHINE which evaluates the mechanical properties of materials. As the jaw of the testing machine moves down, it clamps the workpiece as the machine is operated, data were generated and dynamics of stress-strain curve retrieved from computer program. This shows the stress as a result of strain experienced and it is according to the nature and composition of the material. The data was stored for analysis as shown in result and analysis.

**EQUIPMENT**

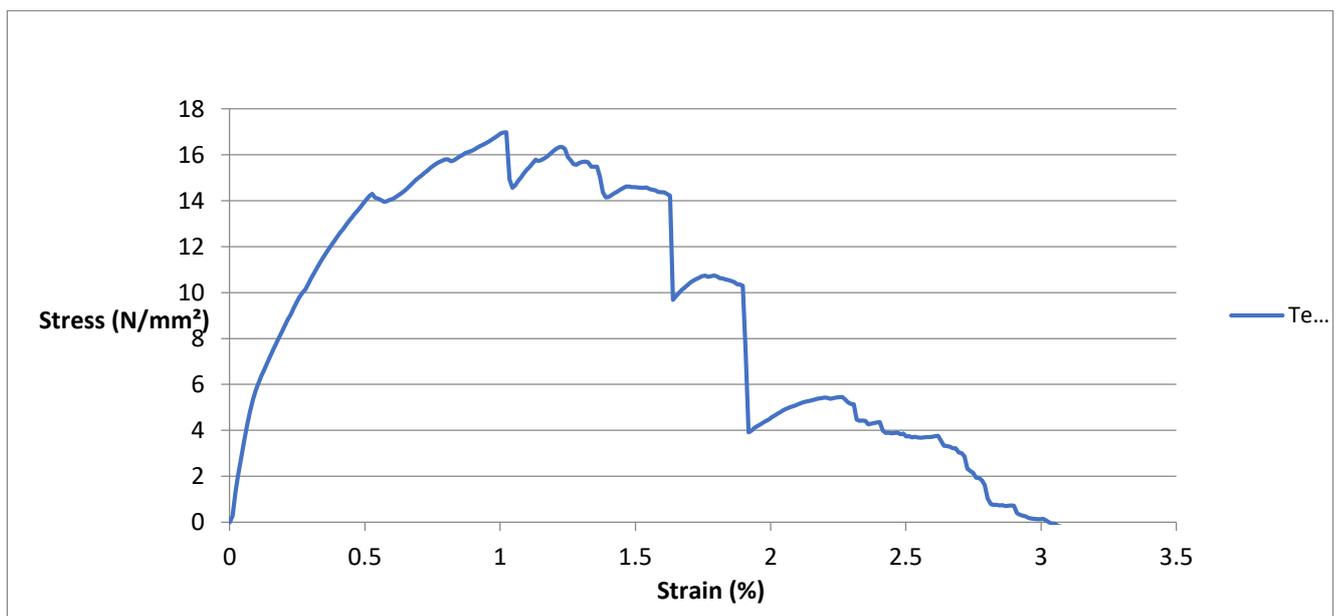
Figure 2 shows the testometric machine, a universal testing machine (UTM) clamping down a sample of plywood for test. It works in such a way that the material or the work piece is placed on the machine and the machine is operated such that the jaw clamps down on the material. The resistance to the moving jaw the generates the requisite data.



**Fig. 2 Testometric machine**

**IV. RESULTS AND ANALYSIS**

The results of the tests are shown as plots in figures 3, 4 and 5 for each of the samples Caledonian, EQ and Viewpoint. Figures 3, 4 and 5 show plot of bending strength in N/mm<sup>2</sup> against strain in (%) for the three selected plywood samples.



**Fig 3: Graph of bending strength against strain for Caledonian, Plywood**

Figure 3 shows that the bending strength at peak for Caledonian was 16.973 N/mm<sup>2</sup>. This was attained from a gradual rise from 0 N/mm<sup>2</sup> stress at 0 (%) strain. The rise was sustained until at about 1% of the strain when it initiates a decline in the bending strength at peak until it gets to 0 N/mm<sup>2</sup> at 3 (%) strain thus signifying an expected sharp drop of bending strength after peak.

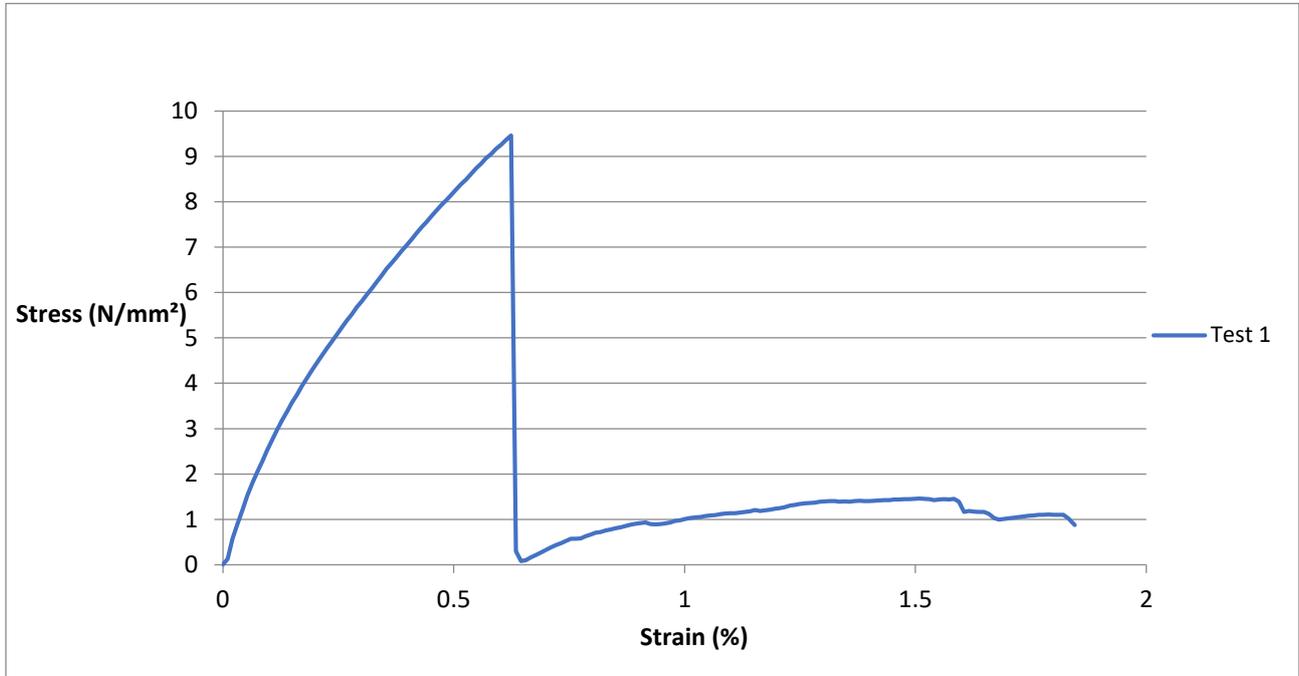


Fig 4: Graph of bending strength against strain for EQ Plywood

Figure 4 shows that the bending strength at peak for Plywood EQ was 9.467 N/mm<sup>2</sup>. There was almost a proportional rise of stress N/mm<sup>2</sup> with the strain % until 9.467 N/mm<sup>2</sup> at strain of 0.62 %. This was succeeded by a steep drop of bending strength at peak.

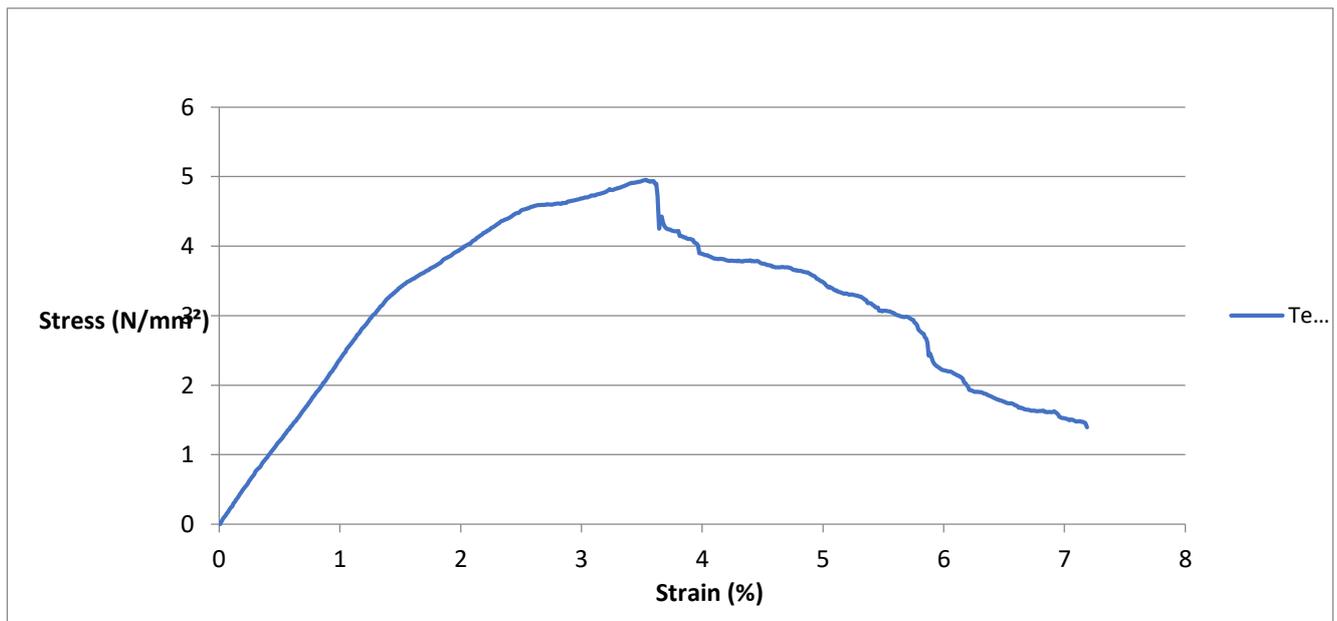


Fig 5: Graph of bending strength against strain for Viewpoint, plywood

Figure 5 shows that the bending strength at peak for Viewpoint was 4.956 N/mm<sup>2</sup>. A gradual rise of stress up to 4.956 N/mm<sup>2</sup> at 3.6 % strain preceded a gradual decline of stress shown as a gentle drop of bending strength.

## V. CONCLUSION AND RECOMMENDATIONS

The flexural test conducted on plywood in Nigeria market reveals that, Viewpoint has 4.956 N/mm<sup>2</sup> of bending strength at peak. Plywood EQ has 9.467 N/mm<sup>2</sup> of bending strength at peak while Caledonian attained 16.973 N/mm<sup>2</sup> of bending strength at peak which incidentally is the plywood in Nigerian market with the highest bending strength at peak as revealed by this research. The values of these modulus of rupture (MOR) arm one with information needed in taking a decision on the choice of make of composite wood (plywood) from the Nigerian market. This averts financial losses associated with failures of substandard plywood in terms of bending strength. Recommendation on future work should be on extending the research to cover marine boards, medium density fiber (MDF) board and high-density fiber (HDF) board.

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