

Flexural Strength Appraisal of Marine Board Plywood in Nigerian Market

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Abstract: Flexural strength appraisal of marine board plywoods in Nigerian market was conducted in a bid to provide relevant technical insights to obviate the superfluous deprivation of earnings frequently encountered with failures when inept marine board plywoods are used for diverse needs due to lack of such knowledge. Painstakingly in a diligent and elaborate approach, the most frequently used as well as common ones across Nigeria markets were identified out of which the first three were selected and subjected to test to establish their bending strength at peak or ultimate bending strength. As required by the testometric machine, the materials were conditioned and tested. Plots of flexural strength versus the associated strain were obtained with computer program from data generated. Analysis show that Marine Plex marine board plywood had the least ultimate bending strength of 17.96 N/mm² while Nplex marine board plywood recorded 21.502 N/mm². Super Plex marine board plywood had the best flexural strength at peak of 65.84 N/mm². Super Plex marine board plywood recorded 0.8516 % strain, Nplex marine board plywood recorded 0.3875 % strain while Marine Plex marine board plywood recorded 0.2471 % strain at their ultimate bending strength. This revelation comparatively reveals Super Plex marine board plywood as the best in Nigerian market based on their flexural strength forbearance. Construction firms and individuals should utilize this novel insight to forestall unwarranted loss of resources arising from marine board failures due to lack of this knowledge. Attention in future should be geared towards a similar research on high density fiberboard (HDF) and medium density fiberboard (MDF).

Keywords: Bending Rigidity, Bending Strength, Creep, Durability, Flexural Modulus, Flexural Stress, Mechanical Test, Modulus of Rupture, Rigidity, Stability.

I. INTRODUCTION

Background of the Study

[1] 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. The plywood industry as well as marine board plywood production has battled with challenges like lack of investment and mismanagement which leads to reliance on importation even as Nigeria possesses abundant timber resources. Marine board plywood history in Nigeria is intertwined with the broader plywood industry which saw a boom in the mid-20th century before it faced series of challenges.

Wood composite is usually made from the same hardwoods and softwoods used for lumber, except using the sawmill's scraps and wood waste, and created by mixing ground wood particles with heated thermoplastic resin. Some combine and process the materials into pellets which are re-melted and formed into the final shape, while others create the final product by a one-step mixing and extrusion process. Both virgin and recycled thermoplastics are used, with polyethylene-based products the most common. UV stabilizers, colorants, coupling agents and lubricants can also be added to create a product specifically targeted to its application, with both solid and hollow shapes formed.

Oriented strand board is made from strands of wood arranged in layers and bonded together using moisture-resistant adhesives. These are then cross-oriented to give the panel strength and stiffness. Laminated timber is created using dimensional timber glued together into structural columns or beams, while laminated veneers bond thin wooden veneers into a large billet which can be used for rafters, beams, columns and joints

One of the main advantages of wood composite is that because it is man-made, it can be designed for specific qualities or performance requirements. It can be made into different thicknesses, grades, sizes and exposure durability, as well as manufactured to take advantage of the natural strength characteristics of wood (and sometimes results in a greater structural strength and stability than regular wood). As a result, it can be used in a diverse array of applications, from industrial scale to small home projects, and enable more design options without sacrificing structural requirements.

Marine plywood is specifically designed for use in applications where it will be exposed to moisture, such as boat building, dock construction, marine structures. Marine plywood is made with water-resistant glue, durable veneers (often tropical hardwoods and specialized manufacturing processes). While all marine board is plywood, not all plywood is marine board. Marine board is a specialized subset of plywood designed to withstand harsh marine environments including exposure to saltwater, humidity, and weathering. Marine plywood often meets specific standards, such as BS 1088 (British Standard) and ASTM D4683 (American Society for Testing and Materials). These standards ensure the plywood's durability and resistance to moisture, fungi, and other marine-related challenges.

Failure of form boards made of plywoods shortly after casting of concretes especially while the concrete is still not yet set has been a major source of concern to the construction industry. Form boards are usually made of various materials including steel, timber, reusable plastic or plywood. To highlight the material's ability to handle bending forces and stresses without failing, flexural strength could be analysed using resistance to bending, which showcases that flexural strength measures how well a material can resist being bent or flexed without breaking or cracking. Ability to withstand stress, which is the material's capacity to handle stress caused by bending forces, which can cause tension on one side and compression on the other is intriguingly riveting. Again, material's flexibility limit which indicates the maximum amount of bending a material can withstand before it fails or deforms permanently and bending failure point is the point at which a material fails or breaks when subjected to bending forces, indicating its limit of flexibility are of great interest when it comes to mechanical properties of materials in engineering applications.

In 2023, Nigerian plywood market is valued at United States dollar 8.81 billion. Through 2024 to 2030, this total revenue is expected to grow to reach about United States dollar 11.05 billion at a compound annual growth rate of (CAGR) 3.3% [2]. In assessment of the impact of inflation on construction material prices in Nigeria between 1998 and 2007, using Lagos state as a case study, in a bid to establish a relationship between inflation and construction materials, [3] observed that inflation rates in Nigeria have been far from stable and have affected building materials prices non-uniformly. In 2024, the global plywood market was valued at USD 50.2 billion with a projection to reach USD 74.5 billion by 2033 at a compound annual growth rate of 4.5% from 2025 [4]. With this price growth either through inflation or growth in demands, it becomes imperative that concerted efforts should be channelled towards maximum resource utilization economy.

Since there is an obvious demand growth at both global and Nigerian level coupled with the projected inflation, technical insight that could lead to appropriate choice of construction materials (marine board plywood) was sought and provided to avoid loss of revenue associated with failure from inappropriate one.

Ultimate Bending strength

Ultimate Bending strength also known as bending strength at peak, or modulus of rupture (MOR), refers to or describes a materials ability to withstand bending forces before failing. Prior to rupturing or failing, it is the maximum possible stress a material can withstand while being bent. Because it is a stress, it has units of pressure ranging from pascal a metric system equivalent of pressure which is Newton per square meter in system international unit SI, to pounds per square inch (psi) in imperial unit of measurement being used in the United States of America and other countries that haven't adopted the metric system as their primary system of measurement. Ultimate bending strength is crucial for marine boards as it determines their durability, that is resistance to cracking and safety. Higher ultimate bending strength in marine boards enhances reliability and increases lifespan. Materials like advanced composites and carbon fibre usually optimize strength-to-weight ratios. In the design and evaluation of materials for applications like structural components, beams and bridges where bending loads are significant, bending strength of the material is very critical.

II. REVIEW OF LITERATURE

[5] evaluated the potential 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. Both physical and mechanical properties of WPC evaluated showed that the tensile strength, face screw holding and modulus of rupture meet the minimum specifications of the US standards. 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 humid and moist environments and even as well as marine use. Strong fibre-matrix interfacial bonding resulted to high mechanical performance. [6] studied the production of highly environmentally-friendly fibreboards by hot-press moulding using *Posidonia oceanica* wastes and a partially biobased epoxy resin as binder. [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 analysing 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. [9] while studying the optimal 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 observed that coconut fibre reinforced HDPE has 28.6 mega pascal as optimum value for flexural strength. [10] while studying the optimization of hardness strengths response of plantain fibres reinforced polyester matrix composites (PFRP) by applying Taguchi robust design observed that empty fruit bunch fibre reinforced polyester matrix composite has the maximum hardness strength of 19.062 N/mm² which depended greatly on the reinforcement combinations of control factors. [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. The resulting fibreboards 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. [12] 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. [13] studied the evolution of surface properties of concrete through measured lightness and absorption and 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. [14] in a very recent research conducted experimental research on analysis of flexural strength of wood composite (plywood) in Nigerian commercial sector and came up with some technical data relevant to wide application and every plywood user. The research came up with a novel finding that Caledonian a make of plywood in Nigerian market recorded 16.973 N/mm², Plywood EQ recorded 9.467 N/mm² and Viewpoint recorded 4.956 N/mm² as the maximum stress, modulus of rupture (MOR) each of them can withstand while being bent before failing or rupturing. From the literature review, it is obvious that research has not been directed towards technical information on marine board in Nigerian market, hence the obvious need for this research paper.

III. RESEARCH METHODOLOGY

Material

Survey was made to identify the three most common and major marine board plywoods in the Nigerian market. The three major marine board plywoods in top demands were Super-Plex, Marine Plex and Nplex. They were obtained and labelled accordingly as found in table 1 and itemized in figure 1 as well. The samples are coded “x”, “y” and “z”.

Table 1. Marine board plywood tested

Sample	x	y	Z
Make	SUPER-PLEX	MARINE PLEX	NPLEX

In figure 1, the samples are as shown below and marked “x”, “y” and “z” representing Super-Plex, Marine Plex and Nplex respectively.

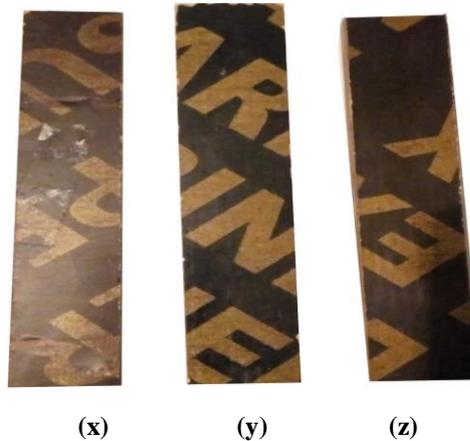


Fig 1: Marine board samples

Equipment

The samples (x) representing SUPER-PLEX (y) representing MARINE PLEX and (z) representing NPLEX were all prepared according to the requirement by the testometric machine shown in figure 2 and tested on the machine one after the other. As required, the materials were prepared by cutting to the dimensions of 30 mm x 200 mm so as to fit in with the testing machine. It operates by moving the jaw of the TESTOMETRIC TESTING MACHINE down to clamp on the workpiece, that is the conditioned marine board plywood samples. Mechanical properties of the marine board plywoods are evaluated during the process. Data is obtained and the dynamics of the stress versus strain plot for the test is obtained with computer program. The plot shows the stress and the associated strain of the material experienced which is the relationship between force per unit area and deformation per unit length in a material under load. This obviously is a function of material composition and its nature. The data generated is analysed in the results and analysis below.



Fig 2: Testometric machine

The universal testing machine (UTM) as seen in figure 2 shows the testometric testing machine clamping down a sample of marine board plywood for test. With the conditioned marine board plywood appropriately placed the jaw of the testometric testing machine moves down in operation to clamp on the material. Resistive ability of the plywood creates force that generates data which aids in the stress versus strain plot generation by computer program.

IV. RESULTS AND ANALYSIS

For each of the samples Super-Plex, Marine Plex and Nplex, the results of the tests are shown as plots in figures 3, 4 and 5 respectively. Basically, showing flexural strength in N/mm^2 against strain in (%), the plots are for the tested samples of the three selected marine board plywoods.

Plots

The plot below is a graph of flexural strength against strain of figure 3 which gradually sustained a rise from 0 N/mm^2 stress at 0 (%) strain to attain ultimate bending strength of 65.84 N/mm^2 at strain of 0.8516 % for Super Plex Marine board plywood while the testometric testing machine was in operation. The ultimate bending strength value as expected, precedes a decline portion of the plot which is the plastic region. Of course, the plastic region succeeds the elastic region just immediately after ultimate bending strength.

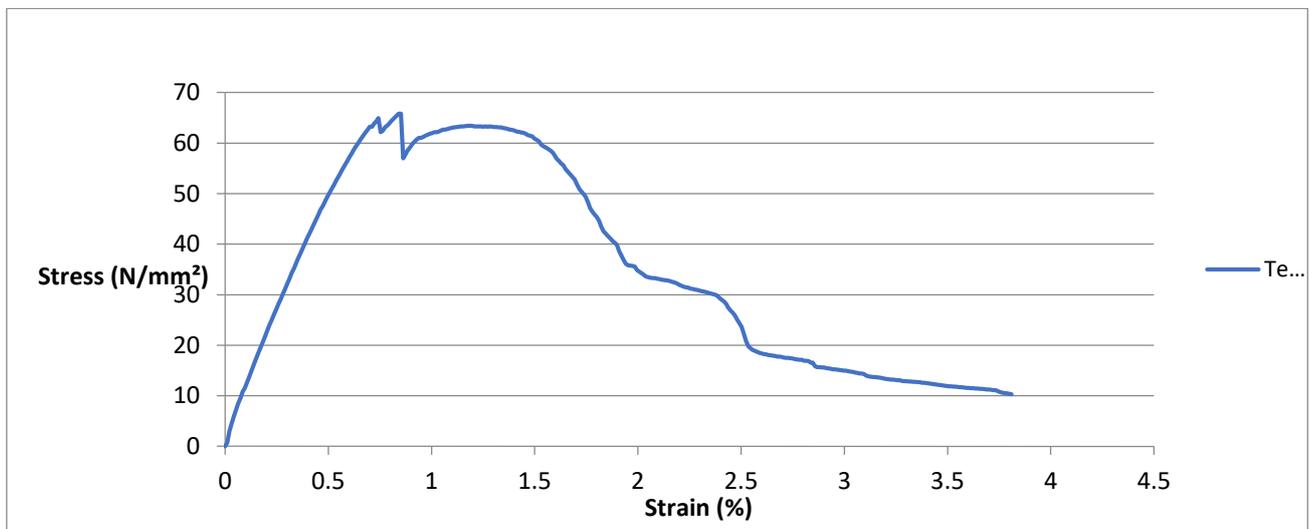


Fig 3 Graph of flexural strength in N/mm^2 against strain in (%) for Super-Plex Marine board plywood

Below is a graph showing the plot of flexural strength against strain of figure 4 which gradually sustained a rise from 0 N/mm^2 stress at 0 (%) strain to attain ultimate bending strength of 17.96 N/mm^2 at strain of 0.2471 % for Marine Plex Marine board plywood while the testometric testing machine was in operation. Again, the ultimate bending strength value as expected, precedes a decline portion of the plot which is the plastic region, while of course the plastic region succeeds the elastic region just immediately after ultimate bending strength.

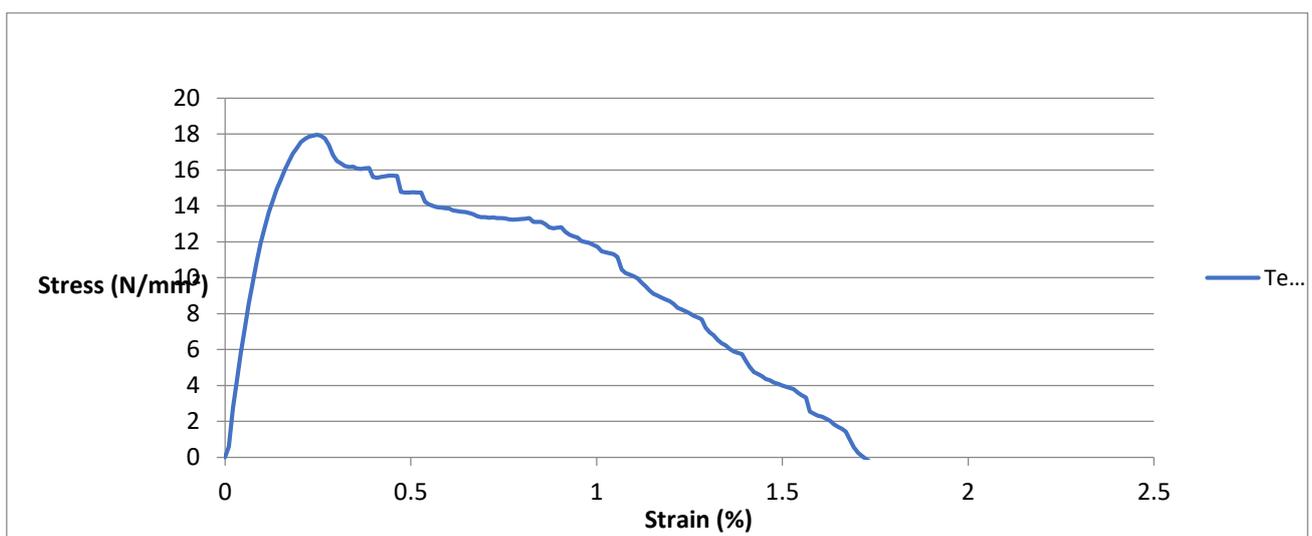


Fig 4: Graph of flexural strength in N/mm^2 against strain in (%) for Marine Plex Marine board plywood

The plot below is a graph of flexural strength against strain of figure 5 sustaining a rise from 0 N/mm² stress at 0 (%) strain to attain ultimate bending strength of 21.502 N/mm² at strain of 0.3875 % for Nplex Marine board plywood while the testometric testing machine was in operation. It is worthy of note that the ultimate bending strength value as expected, precedes a decline portion of the plot which is the plastic region. Again, just immediately after ultimate bending strength, the plastic region succeeds the elastic region.

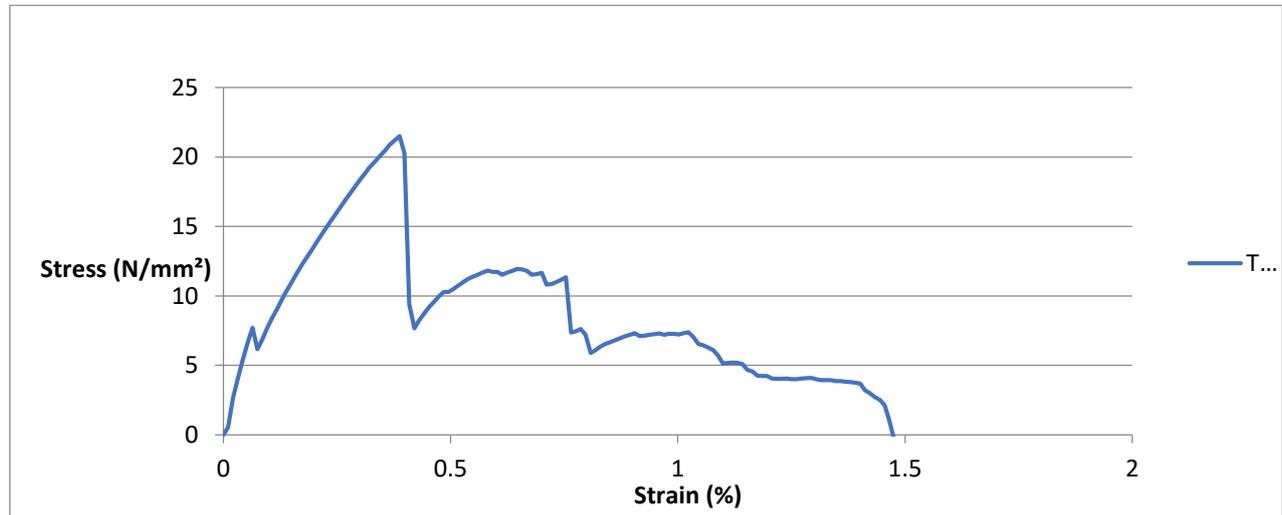


Fig 5: Graph of flexural strength in N/mm² against strain in (%) for Nplex Marine board plywood

V. CONCLUSION AND RECOMMENDATION

Results of flexural tests conducted on three marine board plywoods common and most widely used from Nigerian market show that in a descending order of their ultimate bending strength, Super Plex marine board plywood recorded 65.84 N/mm², Nplex marine board plywood recorded 21.502 N/mm² while Marine Plex marine board plywood recorded 17.96 N/mm². An interesting and similar with respect to descending order trend was also observed in the dynamics of strain at their ultimate bending strength. Super Plex marine board plywood recorded 0.8516 %, Nplex marine board plywood recorded 0.3875 % while Marine Plex marine board plywood recorded 0.2471 %. This observation makes one conclude that a common relationship exists between stress associated with strain in marine boards plywoods in Nigerian markets. These data generated form a wealth of knowledge in choice of marine board plywoods in Nigerian market based on the use which naturally would prevent loss of revenue associated with failure of inappropriate ones. Building contractors, individuals, construction companies even furniture makers should value this novel technical information. Future research works should tend towards that of high density fibreboard (HDF) and medium density fibreboard (MDF).

REFERENCES

- [1] Olorunnisola, A. O. (2023). The past, present and future outlook of the wood industry in Nigeria. Ed: Guanben Du and Xiaojian Zhou, *Chapter Metrics Overview*, DOI: 10.5772/intechopen.105794
- [2] STELLAR, (2025). Nigerian plywood market: Industry analysis and forecast (2024-2030) by application and type. *Market Research Pvt. Ltd.* Report ID: SMR_614
- [3] Ogun, O., Olusola, O. & Chukwudi, U. S. (2014). An assessment of the impact of inflation on construction material prices in Nigeria. *PM World Journal*, (III)IV: 1-22. www.pmworldjournal.net featured paper
- [4] FMRL, (2025). Plywood manufacturing in Nigeria; The feasibility Report. <https://businessplansinnigeria.ng/business-plans/plywood-manufacturing-in-nigeria-the-feasibility-report/#:~:text=Since%201997%2C%20annual%20production%20has,%2C%20the%20UAE%2C%20and%20Austria.>
- [5] Valle, S. (2020). Evaluation of the potential of recycled LPDE and waste sawdust in wood in wood-plastic composite boards. In the book: 2020 ISWA-SWIS Winter School Proceedings. *Solid waste Institute for Sustainability (SWIS), The University of Texas at Arlington.*

- [6] Garcia-Garcia, D, Quiles-Carrilo, L., Montanes, N., Fombuena, V. and Balart R. (2018) Manufacturing and Characterization of Composite Fibreboards with *Posidonia oceanica* wastes with an Environmentally-Friendly Binder from Epoxy Resin. *Materials*, 11(1): 35. <https://doi.org/10.3390/ma11010035>
- [7] Iloabachie, I. C. C., Obiorah, S. M. O., Ezema, I. C., Henry, V. I. & Chime, O. H. (2014). Effects of carbonization on the physical and mechanical properties of coconut shell particle reinforced polyester composite. *International Journal of Research in advanced Engineering and Technology*, 3(1), 62-69, www.engineeringresearchjournal.com,
- [8] Ozioko, F. U. (2011). Effect of carbonized temperature on wear rate behaviour of rice husk ash reinforced epoxy composites. *Leonardo Electronic Journal of Practices and Technologies*, (19); 172-182, <https://lejpt.academicdirect.org>
- [9] Ihueze, C. C., Achike, M. K. & Okafor, C. E. (2016). Optimal performance characteristics and reinforcement combinations of coconut fiber reinforced high density polyethylene (HDPE) polymer matrixes. *Journal of Scientific Research & Reports*. 9(3): 1-10. Doi:10.9734/JSRR/2016/20385
- [10] Okafor, E.C., Ihueze, C. C. and Nwigbo, S. C. (2013). Optimization of Hardness Strengths Response of Plantain Fibers Reinforced Polyester Matrix Composites (PFRP) Applying Taguchi Robust Design. *International Journal of Engineering*. (26)1: 1-11. Doi:105829/idosi.ije.2013.26.01a.01
- [11] Akinyemi. B. A., Afolayan, J. O. & Oluwatobi, E. O. (2016). Some properties of composite corn cob and sawdust particle boards. *Construction and Building Materials* 127, 436-441.
- [12] Aziz, N. A. A., Mohamed, M., Mohamad, M, Amini, M. H. M., Aziz, M. S. A., Yusoff, H. and Rizman, Z. I. (2015). Influence of activated carbon filler on the mechanical properties of wood composites. *ARPJ Journal of Engineering and Applied Services*, 10(1): 376-386. www.arpnjournals.com
- [13] Courard, L., Goffinet, C., Migeotte, N., Martin, M., Pierard, J. and Polet, V. (2012). Influence of the reuse of OSB and marine plywood formworks on surface concrete aesthetics. *Materials Structures* (45): 1331-1343. <https://doi/10.1617/s11527-012-9835-0>
- [14] Ilo, C.P., Ajibo, J. I. & Dim, E. C. (2025). Analysis of flexural strength of wood composite (plywood) in Nigerian commercial sector. *International Journal of Novel Research in Engineering and Science*. (12)1: 30-35. DOI: <https://doi.org/10.5281/zenodo.15687650>