

ASSESSMENT OF LOCALLY MADE LAMINATED VENEER LUMBER FROM *Antiaris africana* UNDER VARIOUS LOADING CONDITIONS WITH MULTIPLE BOLTS

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Atowon, A. D.* Ushie, E. O.* Isemedede, E. E.**

*Department of Wood Products Engineering, Faculty of Engineering
Cross River University of Technology
Calabar, Nigeria

** Department of Civil Engineering Technology,
National Institute of Construction Technology and Management
Uromi, Edo State

atowond@gmail.com, 07030572430,

Abstract

The need to discover new, sustainable and environment friendly building material with considerable strength to weight ratio has necessitated study in different parts of the world. The current study focuses on the production of laminated veneer lumber (LVL) from *Antiaris africana*. Sawn timber of *Antiaris africana* was converted to veneer sheet of (5mm x 195mm x 100mm); the veneer sheet was air dried and further oven dried under a control temperature of 130°C for 3hours to production moisture content of 12%. Urea formaldehyde (UF) resin was used as adhesive. 5ply of veneer sheets were laminated. Test specimens were machined according to appropriate ASTM standards. Experimental result revealed that density of the laminated veneer lumber (LVL); has average value of 403kgm³. Modulus of rupture and shear strength of test samples with steel plate and bolt connectors were recorded as 110N/mm² and 93.3N/mm² respectively while test samples void of metal connectors were reported as 73N/mm² and 33.4N/mm². The study was able to produced engineered wood product viz experimental result revealed suitable raw material input for the construction/furniture design. Improvement of mechanical properties confirmed that steel plate and bolt connectors have good reinforcement and the optimum effect on strength.

Keywords: Engineered wood product, Urea formaldehyde, wood utilization, mechanical properties

1.0 INTRODUCTION

As the result of technological advancement and population increase, there has been a phenomenal rise in demand and use of wood in Nigeria. In view of this, biomaterial (wood) is gradually becoming scarce and expensive. However, there is need to design a new alternative way of using lesser known timber material. Wood is the most abundant biodegradable and renewable material. However, some factors need to be taken into consideration when optimizing its utilization and attention must be paid to economic and, environmental issues, such as emissions of greenhouse gases and threats to forests, which have been effectively fought by the increase in the use of wood. Compared to other resources forests have played a vital role in the development of human societies [1][2][3] and [4]. Studies has approved that wood is of the most multipurpose raw material the world has ever known. So many applications have been made from wood material ranging from building materials, farming tools, bio-energy. In wood-based industries' including timber logging, sawmilling, production of wood-based panels (i.e fibre board, plywood, particles board, and composite) [5] [6][3]. But the un-ending dwindling in wood resource to wood-based industry continue to underscore the need to think beyond absolute dependence on sawn timber. Meanwhile, numerous studies have confirmed the study by China to ameliorated wood scarcity via creation of suitable alternative from many renewable and less known fibrous materials in their locality [8][9][10] The increasing demand of wood for diverse end uses has great range of deforestation. Laminated veneer lumber (LVL) is an engineered wood product which is made of layers of veneers produced from slicing lumber to a predetermined thickness and assembled with adhesives to form a solid wood member. It is used in buildings as adhesives, beams, rim-boards, and edge forming materials [11]. Engineered wood products have become a competitive option worldwide due to emerging technology and building code advances. As building codes allow for larger scale structures to be constructed out of wood, the use of laminate is expected to increase. In building applications with LVL members, connections are commonly made out of steel. Laminated veneer lumber is used in buildings as headers, beams, rim-board, and edge forming material. LVL boasts better fire resistance compared to ordinary beams. This is achieved through multiple layers of veneer and less porosity of material.

settlements and economic resources in floodplains and a decrease of the natural water retention by land use coupled with climate change.

Phenol-formaldehyde resin is neutral to oxidation and doesn't support ignition. High density and absence of cracks prevent from fire propagation and thermal effects inside the material. LVL test results demonstrate the ability of the material to maintain its properties within 30-60 minutes at 300°C. Under the specified temperature, the beam undergoes slow charring at the rate of 0.6 mm/min flatwise and 1 mm/min edgewise. [11][12][13] The present study seeks to manufacture engineered wood product; laminated Veneer lumber (LVL) and evaluate its mechanical properties under various multiple bolt, and further do comparative analysis of the behaviours of engineered wood products (EWP); with bolt and other void of bolt.

2. MATERIALS AND METHOD

Antiaris africana locally known as afara, was obtained from saw milling station, cross river state, Nigeria. Two (2) pieces of Sawn timber size of (100mm x 200mm x 3657mm) were re-sawed using a band saw. Timber was spliced into thickness of 25mm x 200mm x 3657mm. the boards were further reduced to thickness of (5mm x 195mm x 1100 mm) with an electric wood planner.

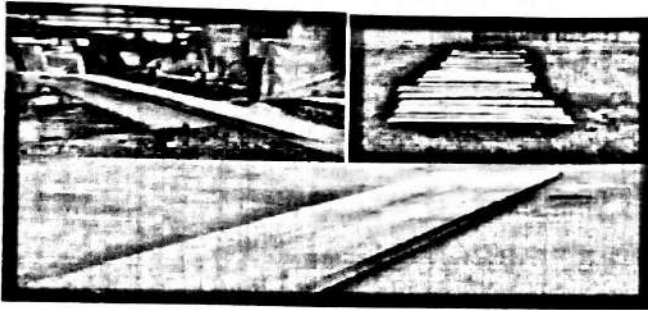
2.1 Drying process

The veneer sheets were air dried for five (5) days to reduce the moisture of the veneer at its green state. The veneer sheets were further oven dried under control temperature of 130°C for 3hours. the veneer sheets were conditioned to 12% moisture content.

2.2 Gluing of the veneer sheets

Urea-formaldehyde (UF) resins were used. (UF) are basically used in the manufacture of products requiring some degree of exterior exposure durability. Urea formaldehyde is one most superior adhesive in furniture and structural work and are cold set (curing). Adhesive were applied on the surface of the veneer using brush method, the ten (10) ply veneer were then press to for proper curing and lamination with the aid of hydraulic pressure of 70bar, for 4hours. LVL of 50mm x 195mm x 1100mm was produced. The laminates were given a surface; end-trimmed and sand with belt sander machine; to required smoothness in compliance with ASTM D 5456[15] Figure 1 depicts the processes involved in the production of laminate from the timber.

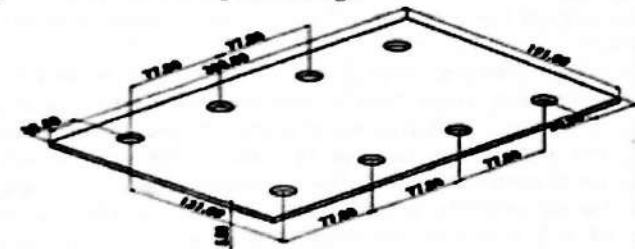
Figure 1: Procedure for manufacturing of laminated veneer lumber



2.3 Design and fabrication of steel plate

According to ASTM A36 [16] mild steel plate of (5mm×590mm×920mm) was purchased from Iron and Steel village; Alaoji, Abia state Nigeria. With aid of Oxyacetylene gas, the steel was cut to smaller dimension of (6mm×191mm×395mm) for the purpose of the study. Total of 8 bolt slots of 16mm were drilled with the aid of pillar drilling machine. The steel plates were sand to required smoothness as shown in fig 2a and 2b: below.

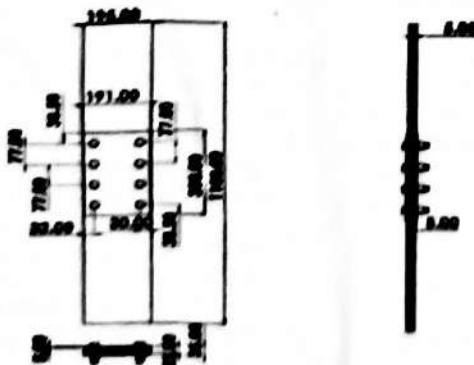
Figure 2a & 2b: Steel plate design



2.4 Bolt connection design Fasteners

According to ASTM A307[16] Grade B, hexagonal bolt of (15mm×100mm) was obtained from the local dealers. Hole of 16mm was drilled on the LVL. Bolt connectors design as shown on figure 3: table 1 below, shows the total number of bolts, design spacing of the steel plate connector.

Figure 3: bolt connectors design



**Table 1:
Bolt design and specifications**

ID	Total no of bolts	End spacing	Bolt spacing	Row spacing	No. of row	No. of bolt in a row	No. of test
A	8	38.50mm	77mm	131mm	2	4	1
B	8	38.50mm	77mm	131mm	2	4	1
C	8	38.50mm	77mm	131mm	2	4	1

settlements and economic resources in floodplains and a decrease of the natural water retention by land use coupled with climate change.

2.5 Tests conducted

The laboratory work examined density, modulus of rupture and shear stress

Density test

Density (ρ) is the mass contained in a unit volume (V) of the material. Each test specimen's density was examined by equation (I) below.

$$\rho = \frac{m}{v}; \quad \rho_0 = \frac{m_0}{v_0}; \quad \rho_k = \frac{m_0}{v_{max}} \quad (g.cm^{-3}; kg.m^{-3}) \quad \text{eqn (I)}$$

Where ρ is density, m - mass, v_{max} volume of LVL.

Modulus of rupture

The modulus of rupture (MOR) of LVL was investigated, total of 10 sample specimens according to ASTM D 345 [15] were tested with Universal Testing Machine (UTM) of 100KN at crosshead speed of 0.001m/s². Five test specimens were void of connectors; and five test specimens were with steel plate connectors. The result values recorded were average values of 5 specimens. Modulus of rupture was determined with equation (ii) below

$$= \frac{3PL}{2bd^2} \quad \text{eqn (ii)}$$

Where modulus of rupture, P is test load (KN) L is length (m), b is width, d is depth, 3&2 are mathematical constant

Shear test

Shear test were conducted in the flat - wise orientation of each specimen using the Centre - point load method, in accordance with ASTM D 5456.[15] Total of 10 sample specimens were tested five void of connectors. Shear stress of LVL was evaluated with equation (iii)

$$\tau = \frac{3P}{2bd} \quad \text{eqn (iii)}$$

Where τ is shear strength, P is test load, b is width, d is depth, 3&2 are mathematical constant

3.0 Result and Discussion

3.1 Density of laminated Veneer Lumber

From the study, it was observed that, the density of laminate produce, its average density is 405kg.m³ at 12% moisture content while that of the solid *Antiaris Africana* timber is 396 kg/m³ at 12% moisture content. This was a mean of all tested specimens. The values of 390 - 480kg.m³ density of *Antiaris Africana* at 12% moisture content was reported by [16][17] and [13] also reported 433kg/m³ at 12% moisture content of solid timber of *Antiaris africana*. This implied that, the average density of the laminated veneer lumber produce has density within the reference template, since density has effect on some mechanical properties engineering materials

3.2 Modulus of Rupture of LVL.

The modulus of rupture (MOR) of laminate void of connector was observed to be 73N/mm² at 12% moisture content while that of the *Antiaris africana* solid timber is 65N/mm² at 12% moisture. This value was a mean of all the tested specimens.

3.3 Shear strength

At 12% moisture content, laminate (LVL) without steel plate is reported to have shear strength of 3.34 N/mm² which is the average shear stress of the tested values, against 4.1N/mm² of solid timber from *Antiaris africana* reported by [16][18] reported at 12% moisture content *Antiaris africana* timber has shear strength of 7.9N/mm². It was observed from the study, the shear strength of the LVL is lower compared to shear strength of solid timber from *Antiaris Africana* at 12% moisture content. Average shear strength of laminated veneer lumber with steel plates and bolt connectors was reported as 93.3N/mm². This is higher than, solid timber of *Antiaris Africana*. Generally, was observed from the study, the laminate with steel plates connector tend to increase the mechanical properties of the laminate with respect to moisture content at 12%.

Conclusion

This study has been able to produced laminated veneer lumber (LVL) from *Antiaris africana*, which is not a well-known timber material in the study area; investigate the mechanical properties with comparison viz laminate with steel plate connectors and laminate without connectors. All sample specimens were seasoned to 12% moisture content for the study, the average density of the laminated veneer lumber produced was recorded as 405kg .m³, higher modulus of rupture and shear strength were observed from steel plate connectors, and moderate MOR and shear strength of laminate without steel plate connectors, compared to the solid timber of *Antiaris africana*,

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