



**ACCESSING THE PROPERTIES AND STRENGTH
OF GLULAM AS LOAD BEARING BUILDING
MATERIALS IN BUILDING CONSTRUCTION IN
NIGERIA.**

A PROJECT SUBMITTED TO THE DEPARTMENT OF
ARCHITECTURE, COLLEGE OF ENVIRONMENTAL SCIENCE AND
MANAGEMENT, CALEB UNIVERSITY,

IMOTA, LAGOS
STATE, NIGERIA.

PROJECT BY:

TITILLOYE STEPHEN OYEBISI..... 17/3997
ODUNUKAN SUBOMI OLASILE..... 18/4998
OGUNTONA DANIEL 17/4091

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE
BACHELOR OF SCIENCE (HONOURS) DEGREE IN ARCHITECTURE.

JULY, 2021

DECLARATION

We **Titiloye Stephen .O.** , **Odunnokan Subomi** and **Oguntona Daniel** hereby declare that this research work presented is carried out under the supervision of Arc Adeola and has not been presented for the award of any degree. All sources of materials used have been duly acknowledged.

.....

Titiloye Stephen .O.

.....

Odunnokan Subomi

.....

Oguntona Daniel

CERTIFICATION

This is to certify that this project dissertation was carried out by

TITILOYE STEPHEN OYEBISI 17/3997

ODUNOKAN SUBOMI OLASILE..... 18/4998

OGUNTONA DANIEL 17/4091

In partial fulfilment of the requirements for the award of Bachelor of Science (B.Sc.) Degree in Architecture, Caleb University, Imota, Lagos.

.....

Titiloye Stephen .O.

.....

Odunnokan Subomi

.....

Oguntona Daniel

.....

Arc. Adeola (Supervisor)

.....

Date

.....

External Examiner

.....

Date

DEDICATION

All thanks to Almighty God, provider of life and sustenance for His Mercies and Guidance always and particularly during the course of conducting research.

ACKNOWLEDGEMENT

All appreciation is because of Almighty God, supplier of life and food, for His leniencies and direction during this course of preparing.

Our obligation goes to our folks and our relatives for their unwavering help in defeating the obstacles throughout everyday life.

We offer our most extreme thanks to the Department of Architecture for the chance given to us to seek after this examination in incomplete satisfaction of the necessities for the level of Bachelor of Architecture.

To our administrator, Arc. Adeola, we offer our thanks for the inspirational perspective and backing he displayed to our work, continually permitting us to test further on issues not satisfactory to us while giving brief reactions with respect to our vulnerabilities on this exploration.

Through everything, we owe our lives and our everything to God who has never retained from us those things that we required most at each stage in life's excursion and most especially, when this investigation kept going.

TABLE OF CONTENT

Title page.....	i
Declaration.....	ii
Certification.....	iii
Dedication.....	iv
Acknowledgement.....	v
Table of Content.....	vi
List of Content.....	ix
Abstract.....	x

1 INTRODUCTION

1.1 Background to the study	1
1.2 Problem Statement	4
1.3 Research Question	5
1.4 Scope of Study	5
1.5 Justification for Study	6
1.6 Definition of terms	6
1.7 Refrences.....	7

2 LITERATURE REVIEW

2.1	Definitions and Description in the field of study	8
2.1.1	Properties of Glulam.....	9
2.2	History of Glulam	11
2.3	Previous studies conducted on the properties and strength of Glulam	12
2.4	Research Gap	14
2.5	Theoretical Framework.....	15
2.5.1	Glulam.....	15
2.6	Conceptual framework.....	16
2.7	References.....	21

3 METHODOLOGY

3.0	Introduction.....	25
3.1	Research Design.....	25
3.2	Data Gathering Methods.....	26
3.3	Data Instrument.....	26

3.4 Data Analysis Technique.....26

3.5 Validity and Reliability of the Instrument.....27

3.6 References.....28

4.0 RESULTS AMD DISCUSSION

4.1 Collation of data29

4.2 Presentation and discussion of findings37

4.3 Summary of findings38

5.0 CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion 39

5.2 Recommendation(s)..... 40

5.3 Contribution to knowledge.....40

LIST OF TABLES

Table 4.1; Gender of the respondents.....	29
Table 4.2; Profession of the respondents.....	29
Table 4.3: Knowledge of respondents on the effect of glulam.....	30
Table 4.4: Knowledge of respondents on usage of glulam.....	30
Table 4.5: Knowledge of respondents on the structural phases of glulam relevance.....	31
Table 4.6: Knowledge of respondents on optimizing technic of glulam	32
Table 4.7: Knowledge of respondents on the free span of glulam	33
Table 4.8: Knowledge of respondents on the unlimited possibilities of glulam.....	33
Table 4.9: Knowledge of respondents on the structural use of glulam.....	34
Table 4.10: Knowledge of respondents on the specification sizes use of glulam.....	35
Table 4.11: Knowledge of respondents on the strength and stiffness over lumber.....	35
Table 4.12: Knowledge of respondents on the efficiency of glulam.....	37

LIST OF FIGURES

Fig 1.1: An Example of Glued Laminated Timber	1
Fig 1.2. Curbed Glulam beams	3
Fig 2.1. Energy efficient buildings constructed with glulam.....	18
Fig 2.2. Glulam benefits with its life cycle.....	21

ABSTACT

The versatility of timber finds wide application in the construction industry spanning from simple framing in housing projects to large scale public facilities. However, limitations of span and cross-sectional dimension, strength reducing defects and anisotropy limits its engineering application. Mechanical methods of jointing to address the earlier challenge has introduced serious wood fiber failure and increased the embodied energy in timber as a green material. However, developed societies have established in literature the possibility of overcoming these limitations in order to use timber for purposes other than its traditional application in Nigeria, such as the development of engineered wood products such as glued laminated timber (glulam) using their timber species. In contrast, while there is little or no interest in timber as a structural material in Nigeria, many of the limited studies that have been done on the material have focused on solid wood features, leaving its limitations unaddressed. Consequently, its structural capabilities is yet unappreciated. Nevertheless, reconstituting natural timber as glulam is an excellent technique of maximizing this green material for a wide range of structural applications. The major goal of this study is to see if these attributes can be achieved with timber. Finally the study serves as a useful survey which may assist in designing with a sustainable material in the future.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Wood has a wide reach in the development business, differing from straightforward casing in lodging tasks to huge scope development projects, development for business purposes. Thusly, it is a characteristic and inexhaustible material, having a high solidarity to-weight proportion and it is not difficult to use during development (Apu, 2003). There are numerous kinds of softwood and hardwood utilized in the development in Nigeria one of which is the Glue covered Timber (Abubakar and Nabade, 2013).

Underlying stuck overlaid wood is created from layers of lumber sheets known as overlays, which are stuck together utilizing sturdy primary glues. They are laid up to such an extent that the granule direction is for the most part corresponding to the long-pivot, all things considered (Green, Gorman, Evans and Murphy, 2006). The interaction of overlays ends up being profitable as various shapes can be made like straight, rectangular or bended cross-areas (Kimeng, 2011). The utilizations of stuck covered lumber goes from private to non-private structures (Willmott, 2010).



Fig 1.1: An Example of Glued Laminated Timber

source//:aida-swings.com

On the off chance that the wood is harmed, it can in any case be utilized for development, as per an article in the New York Times (Regina, 2010). At the point when utilized as a development material, stick covered lumber can be utilized to make numerous species until recently viewed as non-merchantable reasonable for underlying purposes. Ranger service could turn into a significant manager subsequently. As well as sluggish developing trees, glulam can be delivered from quickly developing trees with more modest widths (Evalina, 2010). As an underlying part, glulam comprises of various covers of wood put corresponding to the part's longitudinal pivot. (Carballo, Hermoso and Fernandez, 2009). In many occasions, this is accomplished using Material made by sticking together or compacting layers or pieces of wood in various ways finger-joints or comparable associations are utilized to security diverse lumber parts in a similar level layer to create more extensive ranges (Adedeji and Olu, 2005).

Stuck covered wood can likewise be utilized as burden bearing bars as a choice to steel. Wood as a development material has commonly a lower carbon impression in contrast with steel. It is likewise more adaptable with regards to machining on the structure site and an apparent lumber construction would not need any additional inclusion or cladding according to a building perspective which would lessen the utilization of material. It would subsequently be helpful as far as cost, environment and material use to utilize glulam as burden bearing construction rather than steel.



Fig 1.2. Curbed Glulam beams ;source//:novocom.top

The utilization of glulam has gotten boundless all around the world expanding the cutting edge wooden structure capacities (Anjos, Santos & Simoes, 2011). Likewise in Nigeria, strong wood individuals are progressively being supplanted by current designed glulam, empowering lumber constructions to convey more loads. An illustration of this is the situation of huge range rooftops (Bradbury, Beadle and Potts, 2010). Biodegradable and energy proficient, glulam wood is the most normal and supportable structure material. Material-wise, glulam is significantly more effective than sawn wood. The utilization of glulam diminishes the utilization of crude wood (Tavares, Louzada and Pereira, 2014). Its heap bearing capacities and excellence have been demonstrated in the course of recent years. Timber Glulam is a designed wood underlying material that enhances the specialized properties of an inexhaustible crude material. Glulam permits the creation of extremely large primary parts from more modest trees. (Martins et al, 2019).

Glulam is more grounded and stiffer than underlying lumber of a similar size and thickness. In the event that you consider its own weight, glulam is more grounded than some other development material you can use in your home (Crossman and Simm, 2011). This implies that glulam components can range over significant distances without hanging or breaking. As such with

glulam, draftsmen, building engineers have almost boundless plan decisions, regardless of whether it concerns a private dwelling, a public structure or a traffic connect. (Abrahamsson, 2020).

1.2 Statement of the Problem

There have been a few examinations directed on the properties of Glulam and how it very well may be used in a primary climate. In any case, the vast majority of the investigations have been in outside nations. For example, Martines, Monteiro, Knapic and Dias (2020) surveyed the bowing properties of Glulam blackwood and Sawn in Portugal. They discovered the glulam wood to be preferred for building development over sawn wood. Besides, for projects in nearness to saltwater, Abrahamsson (2020) addresses the possibilities of utilizing reinforced covered wood as burden bearing underlying components. The examination found that as long as the development is above ocean level, glulam can be utilized in sea conditions. Bader and Johannesson (2016) researched the conduct of stuck covered lumber joined with hardwood and softwood lamellae. The investigation found that glulam was helpful to use as a structure development material. Anshari (2012) additionally tried the primary conduct of Glulam lumber radiates supported by packed wood. Supporting Glulam radiates with packed wood blocks is an amazing method to build firmness, twisting strength and burden conveying ability.

In spite of these investigations testing the properties of Glulam and their conduct when open to different climatic components, the greater part of the examinations are restricted geologically as they have not been led in Nigeria. In this manner there is a hole for a Nigerian put together examination with respect to Glulam surveying its qualities and properties in a structure. Consequently this examination expects to take care of this issue and fill the hole in the assemblage of information by surveying the strength and properties of Glulam in a Building

1.3 Objective of the study

The main objective of the project is to assess the strength and properties of Glulam in a Building.

The specific objectives are to:

- 1) To assess the properties of Glulam in a Building.
- 2) To identify the benefits that come with the utilization of Glulam in a building.
- 3) To examine the patterns of the utilization of Glulam in buildings in Nigeria.
- 4) To examine the costs that come with the utilization of Glulam in buildings in Nigeria.
- 5) To determine if the cost of utilization of Glulam in buildings in Nigeria outweigh its benefits.

1.4 Research Questions

There are numbers of research questions that need to be answered and addressed during the study:

- 1) What are the properties of Glulam in a Building?
- 2) What are the benefits that come with the utilization of Glulam in a building?
- 3) What are the patterns of the utilization of Glulam in buildings in Nigeria?
- 4) What are the costs that come with the utilization of Glulam in buildings in Nigeria?
- 5) Does the cost of utilization of Glulam in buildings in Nigeria outweigh its benefits?

1.5 Scope of the Study

The study will focus on assessing the strength and properties of Glulam in Buildings in Nigeria.

The study will be limited in scope to Nigeria. The study will focus on how Glulam is utilized in buildings in Nigeria. It will aim to examine the properties of Glulam that make it beneficial to use in the Nigerian climatic environment. The study will be adopting the qualitative methodology using the ex-post facto research design and the secondary mode of data collections. Data will be

sourced from past studies, newspaper articles and journals that have been done on Glulam and its properties.

1.6 Justification of the Study

The climatic states of Nigeria request an adjustment of the manner in which structures are developed as it has been noted by concentrates in the past that the current method of development in Nigeria isn't economical over the long haul. Thusly, new techniques should be investigated in developing structures in Nigeria. All things considered, this examination evaluating the properties and advantages of Glulam is opportune as it investigates how Glulam can be utilized as a development material to incredible impact in working in Nigeria. The examination will show the manageability of utilizing the Glulam wood as a component of development and it is more valuable than Sawn Wood. The investigation will likewise show the significance of the Glulam wood as far as its expense proficiency and adequacy. It will hence fill in as a base for different examinations to investigate how Glulam can be utilized for other development purposes separated from structures in Nigeria.

Definition of Terms

Glulam: Glued laminated timber, additionally an acronym for glulam, is an engineered wood product composed of dimensional timber glued together using moisture-resistant structural adhesives in order to form a strong and stable structure.

Buildings: Edifices are defined as structures with a roof and walls standing more or less permanently in one place, such as a house or factory.

References

- Adedeji, M., & Olu, O. O (2005). Modern Techniques of Using Timber in Building Structures and Components in Nigeria Department of Architecture, Federal University of Technology, Akure.
- Anjos, O., Santos, A., & Simões, A. (2011). Effect of *Acacia melanoxylon* fiber morphology on papermaking potential. *Appita J.*, 64, 185–191.
- Crossman, M., & Simm, J. (2011). Manual on the use of timber in coastal and river engineering, London: ICE Publishing.
- Green, D., Gorman, T., Evans, J., & Murphy, J. (2006). Mechanical Grading of Round Timber Beams. *J. Mater. Civ. Eng.*, 18, 1(1), 1-10.
- Kimeng, H.T. (2011) Reliability Based Evaluation of Effectiveness of Fasteners and Connection in Timber Trusses. Unpublished Ph.D Dissertation Ahmadu Bello University Zaria Nigeria.
- Martins, C. (2019). Blue gum: Assessment of its potential for load bearing structures. In Proceedings of the 7th International Conference on Hardwood Processing—ISCHP 2019, Delft, The Netherlands, 28–30 August 2019.
- Tavares, F., Louzada, J.L., & Pereira, H. (2014). Variation in wood density and ring width in *Acacia melanoxylon* at four sites in Portugal. *Eur. J. For. Res.*, 133, 31–39.
- Willmott D. (2010). Impacts of Construction and the Built Environment, Briefing note 33 version 1 December 2010.

CHAPTER TWO

REVIEW OF LITERATURE

2.1. Definitions and Description in the field of study

Glulam abbreviation for stick overlaid lumber and is an abridged expression. Various layers of strong wood are stuck or consolidated with solid cement to create a unit of primary association known as a glulam. Glulam is a term utilized by manufacturers to depict all types of covered shafts and other overlaid underlying wood items. Glulam is an adaptable and imaginative development material that is broadly utilized in the business just as in Construction of homes.

A paste covered lumber is a sort of designed wood, which implies it is made of lumber however has been processed and assembled to demanding sizes to offer a structure material that is dimensionally steady Plywood, arranged strandboard (OSB), and overlaid facade wood are generally instances of wood items are altogether instances of designed (plan) wood items (LVL). A glulam bar takes after a pile of 2 x 4s (or bigger wood) with its blasts stuck together.

Some designed parts, including Microlam pillars and LVL (overlaid facade amble), having little layers of wood melded to make a thicker mass and look like extremely thick compressed wood.

Glulam individuals are accessible in an assortment of standard widths and lengths, just as bespoke manufacture to satisfy for all intents and purposes any plan need. They're broadly used to develop vaulted rooftops, vaults, and even extensions with tremendous bending or curving segments. Glulam development beats dimensional wood as far as strength and firmness, and it is more grounded than steel pound for pound. Bolts, steel dowels, and steel plates are normally used to interface glulam radiates. Glulam has the additional advantage of almost boundless shape and size adaptability. Vertical overlays or flat covers (load applied opposite to the wide substance of the

covers) can be utilized to plan and create straight shafts (load applied corresponding to the covers' wide face). The overlay holding can bring about radiates with more prominent strength than the single covers from which they are shaped, which is a critical element of glulam creation. Besides, overlaying empowers for exact control of the situating of various grades of woods inside the cross-part of glulam individuals. Setting the most grounded lumbers in the space of most noteworthy pressure works on the exhibition of glulam individuals (the top and base on account of a twisting part). Covering additionally allows lumber blemishes to be scattered across the length of the glulam area.

2.1.1 Properties of Glue Laminated Timber

The following are properties connected with glulam elements, according to the glued laminated timber association (GLTA, 2006).

a) Strength and weight

A similar glulam shaft might be 20% heavier and 600 percent heavier than a primary steel bar, contingent upon explicit stacking conditions. It is perhaps the most fundamentally vigorous materials as far as weight. It can produce a lighter superstructure than primary steel or cement, bringing about cost reserve funds in establishment building.

b) Chemical Resistance

Wood has a high flexibility to compound fighting in debased conditions and when presented to substance arrangements. It has, truth be told, been utilized for substance tanks and serious tasks, for example, calfskin tanning. Most substances are impervious to the manufactured glues used to join glulam.

Glulam, then again, isn't absolutely impervious to oxidizing specialists. For a model, Alkalis and sulfides, would make the wood mash, because of which fiber and strength are lost. In any case, on the grounds that these are exceptional specialists in by far most of administration enterprises circumstances, glulam ought to be utilized with alert.

c) Durability

The toughness of glulam is influenced by the sort of wood utilized, the paste utilized, and the kind of additive utilized. Glulam can be utilized for the most troublesome of conditions if appropriately indicated. Pool structures are one application where glulam is picked for its perseverance. With high moistness and chlorine levels, this is a very destructive climate, and glulam gives a dependable, low-upkeep arrangement. Glulam is made to make due for quite a few years with very little upkeep.

d) Fire Resistance

Lumber's prevalent warm protection properties, guaranteeing that within a fire-uncovered bit stays cold and basically flawless during the plan Period, just as the charcoal layer that structures on top of it. Thus, uncommon aminating cements' flexibility to fire temperatures, a glulam part acts like it were a solitary element during its helplessness to blazes. As indicated by Bednarek(2008),the scorching pace of lumber relies upon various factors, for example, wood species, lumber thickness, dampness content, substance structure, lumber abandons (for example crevices), the genuine example math (measurements, shape and surface quality)

2.2 History of Glulam

The primary designed wood item glulam is comprised of measurements blunder layers connected also dependable, underlying glues that are impervious to dampness. The substance that gives overlays is known as Laminating stock, frequently known as lamstock, is a kind of material used to make covers in North America.

All through the mid 1890s, Glulam was at first used in Europe. A Swiss patent gave in 1901 denoted the veritable start of stuck covered lumber development. An examination research facility at the USDA Forest Products Laboratory in Madison, Wisconsin, was one of the most punctual glulam structures worked in the United States. The design, which was worked in 1934, is as yet being used today.

The presentation of absolutely water-safe phenol-resorcinol cements in 1942 was a significant achievement in the glulam business. Accordingly, glulam could be utilized in uncovered outer circumstances unafraid of glueline breakdown.

A solitary huge, strong structure part is made by overlaying various little pieces of timber together. Underlying individuals incorporate vertical sections, level bars, and curves. Glulams can be made in bended structures and arrive in a wide scope of animal varieties and looks. Associations are typically made with bolts, steel dowels, and steel plates.

Glulam works on the primary properties of wood. Because of their piece, huge glulam individuals can be fabricated from an assortment of lesser trees reaped from second-development woodlands and ranches.

Glulam offers the strength and adaptability of gigantic wood individuals without the requirement for oldgrowth, strong sawn lumbers. When contrasted with strong sawn lumbers, it limits the generally speaking the amount of wood devoured by lessening the adverse consequence of bunches and other minor subtleties blemishes in every segment board, similarly that other designed wood items.

Glulam has a lower typified energy than built up cement and steel, however it has a higher encapsulated energy than strong wood. The covering cycle, then again, empowers wood to be utilized for far longer ranges, more noteworthy loads, and more unpredictable calculations than built up cement or steel. Glulam is one-10th the heaviness of steel and one-6th the heaviness of cement; the exemplified energy needed to make it is one-6th that needed to create steel of comparable strength. Since glulam is a sort of polymer that can be cut into a huge number of shapes, it permits draftsmen to communicate their innovativeness without losing underlying principles.

2.3 Previous investigations directed on the properties and strength of Glulam

Lee (2005) directed examination on Prediction of bowing properties for underlying glulam using ideal bunch trademark disseminations and laminar MOE. To construct an expectation model for glulam bowing properties, the analysts utilized ideal bunch and modulus of versatility (MOE) circulations of wood cover as fundamental info factors. For this, bunch and MOE information from all bits of lumber ready for glulam make were assessed, and factual disseminations of bunch size, tie number in one wood, and MOE of each overlay were improved as dispersion capacities. These bunch and MOE information were utilized as info factors in the expectation model for twisting

qualities, just as in making virtual glulam utilizing the reverse change technique. The changed portion approach, which is to a great extent depicted in ASTM D 3737, was utilized to foresee bowing boundaries for glulam (Annex A4). This features these species' impressive potential for use in underlying structure materials like sawn wood and glulam. At last, the fifth percentile of the crack modulus and the normal modulus of flexibility were determined utilizing consequences of recreated trial of more than 1000 imaginary glulams to assess the permitted bowing properties of glulam for every particular overlay mix. Twisting properties and circulations for glulam may be anticipated utilized for underlying designing in both allowable breaking point state and stress plans dependent on the discoveries of this investigation.

Additionally, Mohamed et al (2011) explored the Bending Strength Properties of Selected Malaysian Hardwood Timber Glued Laminated Timber. The paper introduced the discoveries of a primer examination concerning the twisting strength conduct of glulam produced using picked Malaysian tropical lumbers, especially resak and keruing, in accordance with MS 758. Four basically upheld disengaged radiates were tried after to the methodology illustrated in BS EN 408:2003. In accordance with MS 544 Part 3, glulam bowing strength was contrasted with the permitted the twisting strength of the lumber. The glulam created passed the essential reasonable worth of solidarity, as per the discoveries. In connection, Martins et al (2020) evaluated the Bending Capabilities of Sawn and Glulam Blackwood in Portugal Their examination uncovered that Portuguese woodlands have changed lately. Rapidly spreading fires that consumed a huge bit of the softwood woodland sped up these cycles. Hardwoods cover 70% of the Portuguese backwoods region, as indicated by information from the Portuguese Institute for Nature Conservation and Forests from 2015. In view of late examinations led at the University of Coimbra and SerQ—Forest Innovation and Competences Center, the investigation featured the Blackwood

(*Acacia melanoxylon* R. Br.) species potential, with an attention on development employments. The damaging and non-ruinous assessment of Blackwood's mechanical characteristics as sawn wood has been read while esteeming it for primary applications. Their capacity was likewise assessed for the glulam, an all the more mechanically created wood item. The Transformed Section Method (TSM) and the Longitudinal Vibration Method (LVM) were utilized to figure the unique modulus of versatility (MOE), while A four-point twisting test was used to decide the static MOE and bowing strength. The two strategies had the option to agree. Sawn Portuguese Blackwood has a thickness of 647 kg/m³, a MOE of 13,900 MPa, and a bowing strength of 65 MPa (mean qualities). The glulam radiates made using this crude material showed more desirable characteristics than sawn wood, most eminently as far as twisting strength, which improved by 29%. This shows these species' extraordinary capacity and guarantee for utilization in underlying development products, for example, sawn wood and glulam.

2.4 Research Gap

In industrialized nations, especially in America and Europe, primary glulam individuals have been often utilized. These individuals are utilized in the development of game edifices, business structures, places of worship, and private homes, either straight or bended. Lamentably, except for a special venture done by the Forest Research Institute of Malaysia (FRIM) during the 1970s, no developments in Malaysia have used glulam. Because of the impressive inborn material changeability, compelling utilization of glulam in development requires a comprehension of the primary conduct of different species and species groupings. To have the option to advance the utilization of glulam in Malaysia, more information on

glulam made utilizing Malaysian native species, like mechanical qualities, bondability, and strength, are required.

A vital differentiation among lumber and other underlying materials is that wood is a living material, making it harder to accomplish execution principles, while steel is fabricated for a particular capacity. The gigantic assortment of tropical hardwoods accessible for primary purposes exacerbates joining a particular types of lumber with indicated execution standards. There is as yet a need to obtain configuration esteems for glulam strength and solidness utilizing more exact, viable, and measurable techniques that don't have the basic issues that have tormented past models being used.

2.5 Theoretical Framework

2.5.1 Glulam

Juan Rodriguez (2019) characterized glulam as "stick covered wood is a curtailed expression for stick overlaid lumber. A glulam is a primary unit comprised of various cuts of strong lumber stuck n combination with a high-strength glue Glulams are a term utilized by developers to allude to a wide range of covered pillars or other overlaid underlying wood segments.". The meaning of (Kitek Kuzman et al., 2010) is somewhat unique in relation to that of Juan Rodriguez: "Glulam (otherwise called stuck covered lumber, overlaid wood, glulam pillar, or conventional glulam) is a composite material that has a more uniform dispersion and higher mechanical properties than wood." (Roberto Crocetti et al., 2013), based on his definition expressing the numerical condition of glulam as "STRENGTH X PERFORMANCE X BEAUTY = WOOD³ = GLULAM".

Juan Rodriguez definition is the most applicable to this point of study, giving the accentuation on which wood stumple bonds together to shape a solitary wood blunder having a higher rigidity than an ordinary layer of strong wood amble, they play a huge impact in distinguishing the strength of glulam.

Wood has stayed a significant structure material since antiquated occasions. Being a woodland item, its base inherent energy makes it an economical material. It is additionally known to show ozone harming substance balance and undeniably less energy than other structure materials is needed in preparing to completed item (Regina et al., 2010; Dorina et al., 2012).

The properties of wood are known to shift with species, age, site and natural condition. Examination principally resolves the innate issues related with the utilization of lumber through series of test to work on its unwavering quality and foster composite results important to general society. Lumber can be utilized to support a house from floor to rooftop. This reality is verified in "The hypothesis of tall wood structures" which as per Chui (2013) isn't new giving a 2012 study 15 led uncovering that there are 125 post and shaft structures in Greater Toronto Area with no less than 37 buildings 5-8 stories worked between 1872 – 1933 while the majority of it between 1910-1920.

Not that Kitek Kuzman model isn't significant but rather Juan Rodriguez hypothesis is fundamental for this investigation: it permits us to sort out degree to which the strength and properties can be moreover clarified and where improvement can be made.

2.6 Conceptual framework

Energy Efficient Buildings

In contrast with common constructions, energy-effective structures utilize less energy while keeping up with or in any event, working on inhabitant solace. They have less natural effect and are additionally monetarily suitable and tough, (FMHLUD, 2015). It is a structure that is intended to limit energy interest and outfitted with proficient hardware and materials proper for the area, use, and conditions, which is run so that outcomes in a low energy use when contrasted with other comparative structures (Meier & Olofsson, 2002). They are structures that are planned so that energy is utilized at a lower cost, in a manageable and protected way. Energy-productive development is a remedy for accomplishing a "practical city or eco-city" (Eco-city, 2011., Nwofe, 2014). Since to issues like obliviousness/ignorance, destitution, an absence of information, as well as awful government approaches pointed toward achieving such standards in structures, energy productive structures are basically obscure in Nigeria (National Bureau of Statistics, 2010., Murtala et. al., 2013).

As per Kornels, B. et al (2007), to accomplish an energy proficient structure, a way to deal with coordinated plan is an essential to ensure that the building segments and designing frameworks connect adequately. Decrease of warming, cooling and lighting loads, use of dynamic sunlight based energy, just as other warmth sources and sinks in the climate, expanding the proficiency of machines, warming and cooling gear and ventilation, determination of an elite wrap and high productive hardware are a portion of the endeavors recommended for making building energy proficient. as indicated by CREDC (2009) in accomplishing an energy productive structure, it is

significant that key perspectives like structure Window direction, size, and concealing, rooftop and divider protection, and utilization of warm mass (heat engrossing) material, cross ventilation, arranging, and energy proficient apparatuses be thinking about. Contingent upon the construction and space type, the particular energy-saving procedures, techniques, and cycles to be carried out will fluctuate significantly. Environment, inside heat gains from occupants and their exercises, lights and electrical gear, building size and massing, brightening (lighting) necessities, long periods of activity, and expenses for power and other fuel sources will all effect their determination and compliance (DOE, 2001).



Fig 2.1. Energy efficient buildings constructed with glulam source//:okohausger.com

The Benefits of Energy Efficiency

Structures are responsible for almost 33% of worldwide energy use and 40% of every single mined material and 36% of CO₂ outflows (Straube, 2006) Enhancing structure energy execution is a savvy approach of battling environmental change and further developing energy security while

additionally extending open positions, especially in the development business (Mohsen, 2011). Local area Research and Development Center CREDC (2009) stated that Energy effectiveness has become a significant part of reasonable turn of events, the utilization of energy productivity will bring about close to home pay investment funds; individuals won't need to go through such a lot of cash paying for energy. It will help to restrict the development of new influence plants, permitting cash to be spent on different spaces of the economy rather than power plants. In Nigeria, the insufficient stock of energy made it vital for energy to be divided/apportioned, however with great energy the board at the private, public and private area, there will be no compelling reason to proportion power supply. It was additionally affirmed that Nigerian energy is gotten from the burning of petroleum products like oil and gas. For each kilowatt-hour of power utilized; there is an identical measure of ozone depleting substance outflows (GHGs). Energy effectiveness can help decrease dependence on oil just as ozone harming substance emanations. furthermore, diminish the negative ecological impacts connected with energy age (CREDC, 2009). Numerous people can be selected during mediation projects to change individuals' conduct so they use energy all the more viably, yet there are extra methodologies going from retrofitting or using energy productive apparatuses to making an energy effective structure that is harmless to the ecosystem. There will be insignificant or no utilization of energy in doing as such. Organizations that make electrical machines will confront rivalry from each other; the individuals who make the most energy-efficient items will win buyer favor.

A recent report on the procedure for energy effectiveness, bring up the advantages of energy preservation as follows:

I. Financial development: Energy proficiency estimates when fixed regularly require neighborhood labor , and accordingly the endeavor has the probability of upgrading work and monetary cycle .

There are long haul development benefits, for example , it brings down homegrown energy charges, this will cause higher expendable wages which will be spent somewhere else inside the economy, while organizations can see a markdown in running costs then an ascent in efficiency.

ii. Development of energy productive innovation: this offers a more extended term interest in energy effectiveness advancements can make an ethical circle since development lessens costs, making it less expensive and simpler to put resources into energy proficiency later on. Fostering our innovative limit in energy productivity advancements, materials, or plans of action raises the chance of all the more enormous fare possibilities for Nigeria as the worldwide mission to fight environmental change increase.

iii. Usefulness gains: Economic investigations exhibit that better energy proficiency can help efficiency, builds development and lessens expansion. This gives extra positions because of the total effect of higher development.

iv. Reserve funds for family and corporate buyers: are basic to giving a reasonable proposal to the customer. Advantages like expansions in energy proficiency, like protection and warming effectiveness, the arrangement of energy-saving strategies enormously diminishes the energy use in structures with investment funds on a structure's energy bills.

v. Expanded general prosperity: Good wellbeing can be improved with expanded energy productivity, like a higher discretionary cashflow; lower energy bills can take into consideration

expanded spending on different necessities. Energy saving arrangements that are appropriately introduced can have significant medical advantages.

vi. Discharge decreases: In request to battle contrary to ozone depleting substance outflows which has been the to meet our objectives throughout the following not many a very long time in the most practical manner conceivable, we need energy proficiency to improve significantly across all areas, since energy effectiveness is a financially savvy elective.

vii. A safe and long haul energy framework: when energy utilization is diminished there is improvement in energy security. Diminished interest can likewise have extraordinary advantages for the energy framework since it limits the drawn out need for additional foundation venture that would somehow or another be important. Later on, this can possibly bring down the general expense of the energy.

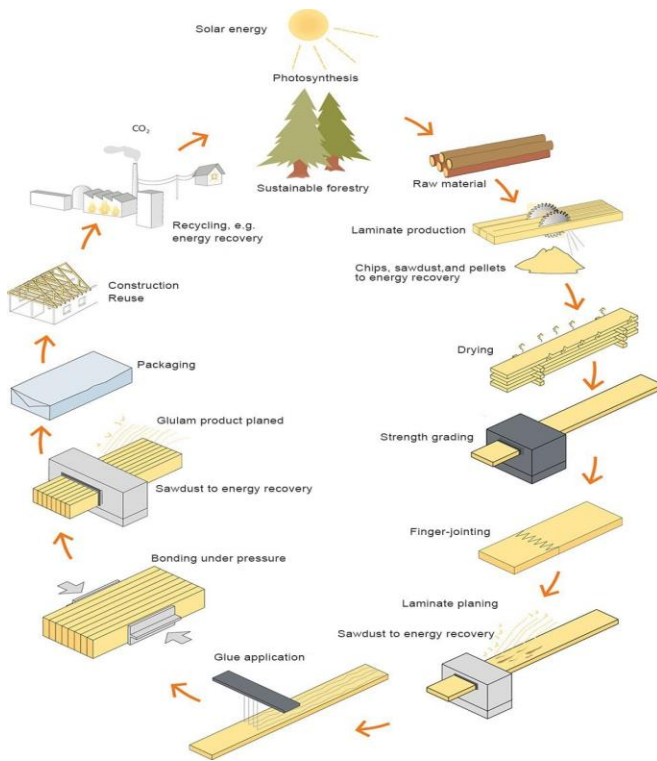


Fig 2.2. Glulam benefits with its life cycle source//:swedishwood.com

References

Bjelanović, A., & Rajčić, V. (2007) Drvene konstrukcije prema europskim normama (Timber Structures according Eurocode), Zagreb, Croatia. Hrvatska sveučilišna naklada i Građevinski fakultet Sveučilišta u Zagrebu (University of Zagreb, Faculty of Civil Engineering), 2005, pp. 1-457.

Burgbacher, C. (1991). Geformtes Holz ist umweltfreundlich, energiesparend und leistungsfähig. Bauen mit Holz, 5: 327-332.

Bocquet, A.P.; Despres, A.; Mansouri, H., R.; Resch, L.; Michel, D.; Letort, F., (2007). Wood joints and laminated wood beams assembled by mechanically-welded wood dowels. J. Adhesion Sci. Technol., 21 (3–4): 301–317.

Cook, Geoffrey M. (1997) [A Higher-Order Bending Theory for Laminated Composite and Sandwich Beams](#) - [NASA Technical Reports Server \(NTRS\)](#) 1997-01-01

Cook, Geoffrey M.; Tessler, Alexander (1998) [A {3,2}-Order Bending Theory for Laminated Composite and Sandwich Beams](#) - [NASA Technical Reports Server \(NTRS\)](#) 1998-01-01

Frühwald, A. (2005) Comparison of wood products and major substitutes with respect to environmental energy balance. University of Hamburg, Centre for Wood Science and Technology, Federal Research Center for Forestry and Forest Products.

Haiman, M.; Rak, M. (2003) Testing the timber glulam beams strengthened with CFRP plates. Proceedings: Second International Conference of the European Society for Wood Mechanics. Stockholm, Sweden: STFI Stockholm, 343-348.

Iimura, Y.; Kurita, S.; Ohtsuka, T. (2006) Reticulated Timber Dome Structural System Using Glulam with a Low Specific Gravity and its Scalability. Proceedings of WCTE 2006 - 9th World Conference on Timber Engineering - Portland, OR, USA - August 6-10, 2006. http://www.ewpa.com/Archive/2006/aug/Paper_009.pdf

Johnsson, H.; Blanksvard, T.; Carolin, A. (2007) Glulam members strengthened by carbon fibre reinforcement. *Materials and Structures* 40 (1): 47-56.

Mackerle, J. (2005) Finite element analysis in wood research: a bibliography. *Wood Science Technology* 39: 579-600.

Möhler, K.; Blumer, H., (1978) Brettschichtträger veränderlicher Höhe, *Bauen mit Holz* 8: 406-410.

Möhler, K.; Hemmer, K., (1981) Eingeleimte Gewindestangen. V: *Bauen mit Holz*, 5: 296-298.

Müller, A., (2000) *Holzleimbau*. Birkhäuser, Basel-Berlin-Boston. 12. Natterer, J.; Herzog T.; Volz, M., 1996: *Holzbau - Atlas*. Rudolf Müller, Köln: 101.

Prof Pakinar, G.K “ Theory of Architecture as a Basis of for Architectural Education and Practice” In seminar on Architecture, 97-100

Stungo, N. (2001). *Wood: New Directions in Design and Architecture*. San Francisco, California, USA: Chronicle Books.

Šernek, M.; Resnik, J.; Kamke, F.A. (1999) Penetration of liquid urea-formaldehyde adhesive into beech wood. Wood and Fiber Science, V. 31(1).

Tessler, Alexander; Gherlone, Marco; Versino, Daniele; Di Sciuva, Marco (2012) - [Analytic and Computational Perspectives of Multi-Scale Theory for Homogeneous, Laminated Composite, and Sandwich Beams and Plates](#) - [NASA Technical Reports Server \(NTRS\)](#) 2012-01-01

Winter, W., (2004) Bausysteme Holzbau: C Holzeinsatz bei Tragwerken: Praktische Hinweise zur entwicklung von Tragwerken. Institut für Tragwerkslehre und Ingenieurholzbau, TU.

Žagar, Z (2002). Timber structures I, II. Zagreb, Croatia: Pretei.

Regina L Y, James W, Thai N and Szymon B (2010): An Investigation into the Use of Glue Laminated Wood in Construction.

Chui, Y. H. (2013,). What's New in Wood Building. Atlantic Woodworks. Atlantic Woodworks Presentation February 26, 2013.

Manja Kitek Kuzman, Leon Oblak1 , Srečko Vratuša (2010): Glued Laminated Timber in Architecture. DRVNA INDUSTRIJA 61 (3) 197-204 (2010).

JUAN RODRIGUEZ (2019). Article on what are glulam timbers and how they are used?
<https://www.thebalancesmb.com/what-is-glulam-applications-and-advantages-of-glulam-845106>

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This section portrays the examination approach that was suggested. It comprises of the accompanying components: research configuration, study populace, examining/inspecting procedure, information gathering and examination instrument, legitimacy and unwavering quality of information creation instrument.

3.1 Research Design

This examination follows the ex-post facto plan of study to help an appropriate appraisal of the strength and properties of Glulam in a Building. This technique empowers the scientist to screen and connection changes that happen throughout a specific time-frame to give a clarification to why such changes happen. The ex-post facto research configuration depicts changing examples clearly and builds up the course and extent of causal connections. In view of past conditions, this system helps the scientist in anticipating the future aftereffects of such affiliations (Rajulton, 2001: 172). The ex-post facto research configuration is for the most part used to inspect gross and unit-level changes, just as total proportions of the strength and precariousness of such information (Lynn, 2009: 12).

The ex-post facto research configuration illustrates the extent of causal communications. In view of past conditions, this methodology helps the scientist in anticipating the future consequences of such affiliations (Rajulton, 2001). Accordingly the utilization of pattern designs in ex-post facto the plan empowers the scientist to lead numerous examinations about the strength and properties of Glulam in a Building.

3.2 Data Gathering Methods

Information assortment is the way toward get-together and estimating data on the objective factors to address questions and assess related outcomes. This segment gives a response to the subject of how information was assembled. It depicts information sources, information assortment instruments, and the legitimacy and unwavering quality of instruments. The use of optional information was utilized in gaining the information required for the fruition of this undertaking. This data was assembled with the particular objective of assessing the strength and attributes of Glulam in a structure.

Optional information incorporates the substance of past versions of papers, curios, articles, and diaries that are identified with Glulam and its utilization in the development business.

3.3 Data Instrument

Most of the data in this investigation came from auxiliary sources. In this examination, important books, diary articles, periodicals, papers, unpublished papers and propositions, and institutional distributions were utilized. The optional information utilized in this examination are gotten from the past research concentrates on Glulam and other pertinent wellsprings of information.

3.4 Data Analysis Technique

Literary examination fills in as a device for information investigation, permitting the specialist to fundamentally assess the occasions of kid assault and the administrative establishment for

defending of youngster Rights in Nigeria. It was embraced on the grounds that the impediments of the examination like the analysts' area and funds would not allow the specialist to get to essential information. Besides, the scientist chosen not to direct meetings with chose people (test) to keep away from predisposition. Along these lines, printed investigation presents the best method for evaluating the strength and properties of Glulam in a Building.

3.5 Validity and Reliability of the Instrument

Legitimacy cautiously endeavors to ensure that the embraced instrument contains and applies hypothetical information inside the part of what's being examined. It likewise guarantees that inside the sense, the instrument is legitimately intelligent of the point matter under examination. This investigation receives the intelligent Approval. This approval instrument will assist with directing the analyst towards distinguishing the different reactions to a comparable issue (Bierner and Lyberg: 2003: 42). The instrument used in this examination will be approved by my boss and individuals who have complete information on the world under investigation. Unwavering quality considerations with the degree of constancy and consistency inside the information inferred. This investigation receives the Alternate Forms Reliability.

REFERENCES

- Bainbridge, J. (2004). *Tools 3: Textual Analysis and Media Research*. London: Sage.
- Biemer, P. and Lyberg, L. (2003). *Introduction to Survey Quality*. New York: John Wiley & Sons, Inc.
- Black, R. (2016). *Institutional Structure and Decision-Making Process*. Retrieved on 22 January, 2018 from <http://slideplayer.com/slide/69636180/>
- Buck, N., Ermisch, J. and Jenkins, S. (1995). *Choosing a Longitudinal Survey Design: The Issues*. University of Essex : ESRC Research Centre on Micro-Social Change.
- McKee, A. (2003). *Textual Analysis: A Beginner's Guide*. London: Sage.
- Rajulto, F. (2001). The Fundamentals of Longitudinal Research: An Overview, *Special Issue on Longitudinal Methodology, Canadian Studies in Population*, 28(2), 2001, pp. 169-185
- Trochim, W. (2006) *Types of Reliability, Social Research Methods-Knowledge Base*. Retrieved December 29, 2017 from <https://knowledgebase.com/type-of-reliability-and-social-research-method/html>

Chapter Four

C

4.1: The findings of the study are reported in the tables below;

Table 4.1; Gender of the respondents.

Gender	Frequency	Frequency%
Male	20	36.3
Female	35	63.7
Total	55	100%

The gender of the responders is shown in the table above.

Table 4.2; Profession of the respondents.

Profession	Frequency	Frequency%
Architect	18	32.7
Structural engineer	20	36.5
Urban/town planner	2	3.6
Student	15	27.2
Total	55	100%

This profession of the responders is shown in the table above.

Table 4.3: Information on respondents on the acceptability glulam has on building component in there respectful construction.

Does the use of glulam has an effect on building designs and structures?	Frequency	Frequency%
Yes	32	58.1
No	23	42
Total	55	100%

This table displays respondents' awareness on how glulam has an effect on building designs and structures. 58.1% of the respondents believe that glulam has an effect on building designs and structures, while 42% do not.

Table 4.4: Information on respondents on how long glulam has been exposed to the usage of glulam as a building material.

How long have you been using glulam ?	Frequency	Frequency%
Below 5 years	18	32.7
5-10 years	16	29
Above 10 years	21	38.1
Total	55	100%

This table displays respondents' awareness on how long have you been using glulam. 32.7% of the respondents have been using glulam for below 5 years, 29% have been using glulam for 5-10 years, while 38.1% have been using glulam for above 10 years.

Table 4.5: Information on respondents on the usage of glulam as structural or nonstructural building component

In which of the structural phases is the glulam most relevant?	Frequency	Frequency%
Foundation	9	16.3
Wall partitioning	10	18.1
Casting of beams	26	47.2
Roofing	9	16.3
Others	5	9
Total	55	100%

This table displays respondents' awareness on which of the structural phases is the glulam most relevant. 16.3% of the respondents revealed that glulam is relevant in the foundation, 18.1% revealed that glulam is relevant in wall partitioning, 47.2% revealed that glulam is relevant in casting of beams, 16.3% revealed that glulam is relevant in roofing.

Table 4.6: Information on respondents on glulam is renewable as a building material.

Glulam is a structural material that improves the technical properties of a renewable raw material timber?	Frequency	Frequency%
Strongly Agree	17	30.9
Agree	13	23.6
Undecided	4	7.2

Disagree	10	18.1
Strongly Disagree	11	20
Total	55	100%

This table displays respondents' awareness on glulam as a structural material that optimizes the technical properties of a renewable raw material lumber. 30.9 % agreed that glulam is a structural material that optimizes the technical attributes of a renewable raw material lumber, while 20% strongly disagreed.

Table 4.7: Information on respondents on how glulam elements can span freely over great distances.

How long can glulam elements span freely over great distances in an open space?	Frequency	Frequency%
30m	11	20
20m	20	36.3
Above 30m	3	5.5
Below 30m	12	21.8
undecided	9	16.3
Total	55	100%

This table displays respondents' awareness on how glulam elements can span freely over great distances. 36.3% of the respondents agreed that glulam elements can span freely over great distances of 20m in a free space, while 16.3% are did not decided weather glulam elements can span freely over great distance.

Table 4.8: Information on respondents on flexibility to create structural design with the usage of glulam.

Architects and building engineers have nearly limitless options for creating their own structural designs when using glulam.	Frequency	Frequency%
Strongly Agree	15	27.2
Agree	21	38.1
Undecided	6	10.9
Disagree	8	14.5
Strongly Disagree	5	9
Total	55	100%

This table displays respondents' awareness of how architects and building engineers may create virtually limitless structural designs with glulam. 38.1 percent agreed that architects and building engineers have nearly endless options to create their own structural systems using glulam, while 9 percent strongly disagreed.

Table 4.9: Information on respondents on the usage of glulam as a structural member to span spaces as beam or arches.

Glulam can be used for beams or arches	Frequency	Frequency%
Strongly Agree	20	40
Agree	20	40
Undecided	7	12.7
Disagree	3	7.3
Strongly Disagree	0	0
Total	55	100%

This table displays respondents' awareness on how glulam can be used for beams, arches or columns. 40% of the respondents agreed that glulam can be used for beams, arches or columns, while 0% strongly disagree that glulam can be used for beams, arches or columns.

Table 4.10: Information on respondents on the flexibility of the usage of glulam members in building component.

Glulam members come in a variety of conventional widths and lengths and can be custom-fabricated to meet any design specifications.	Frequency	Frequency%
Strongly Agree	12	21.8
Agree	9	16.3

Undecided	8	14.5
Disagree	16	29
Strongly Disagree	10	18.1
Total	55	100%

This table displays respondents' awareness as to how glulam members come in a variety of conventional widths and lengths that can be custom-fabricated to meet any design specifications. 21.8 % strongly agreed that glulam members have multiple standard widths and lengths that can be custom-fabricated for any design specifications, while 18.1 % strongly disagreed.

Table 4.11: Information on respondents on the strength of glulam as against non-laminated timber.

Glulam construction surpasses dimensional lumber in terms of strength and stiffness and pound for pound.	Frequency	Frequency%
Strongly Agree	18	32.7
Agree	11	20
Undecided	6	11
Disagree	15	27.2
Strongly Disagree	8	14.5
Total	55	100%

This table displays respondents' awareness of how glulam construction outperforms dimensional lumber in terms of strength and stiffness pound for pound. 32.7 percent of respondents strongly believe that glulam construction is stronger and stiffer than dimensional lumber, pound for pound, while 14.5 percent strongly disagree.

Table 4.12: Information on respondents on the efficiency in terms of thermal insulation of glulam.

The use of glulam ensures building efficiency in terms of temperature control	Frequency	Frequency%
Strongly Agree	12	21.8
Agree	19	34.5
Undecided	5	9
Disagree	9	16.3
Strongly Disagree	10	18.1
Total	55	100%

This table displays respondents' awareness on how the use of glulam ensures building efficiency in terms of temperature control. 34.5% of the respondents agreed that the use of glulam ensures building efficiency in terms of temperature control, while 16.3% disagreed that the use of glulam ensures building efficiency in terms of temperature control.

4.2: Discussion of findings

According to the study's findings, it showed that glulam is a relevant tool in construction and designs of buildings, also it has multidimensional uses in the built environment. Where 58.1% of the respondents believe that glulam has an acceptance on building designs and structures, also 31.8% of the respondents revealed that glulam can enhance the initial stiffness, while 61.8% revealed that glulam can enhance load bearing capacity and bending strength, meanwhile 30.9% of the respondents strongly agreed that glulam is a structural material that improves the technical properties of a renewable raw material, wood., another 32.7% of the respondents have been using glulam for below 5 years, 29% have been using glulam for 5-10 years, while 38.1% have been

using glulam for above 10 years, in addition 32.7% of the respondents strongly agree that glulam structure outperforms dimensional timber in terms of strength and stiffness., and pound-for-pound, while 38.1% of the respondents agreed that architects and building engineers have virtually unlimited possibilities to create their own structural designs with the use of glulam.

4.3: Summary of findings

The investigation was done to get to the actual strength and properties of glulam. The discoveries was resolved with the guide of a poll which calls attention to the attributes for the utilization of glulam as a primary component. The discoveries for the most part with the assistance of surveys was made prominent and concurred on that glulam is a decent primary material for development which can guarantees building proficiency as far as temperature control, glulam can be utilized for bars, curves or sections and glulam individuals have diverse standard widths and lengths which can be specially crafted to meet any plan details.

Chapter Five

Summary, Conclusion and Recommendations

5.1 Summary

There are numerous kinds of softwood and hardwood utilized in the development in Nigeria one of which is the Glue overlaid Timber.

Underlying stuck covered lumber is manufactured from layers of Laminates are wood boards that have been overlaid, which are stuck together utilizing strong primary glues (phenol-resorcinol 35 formaldehyde(PRF), delivered from resorcinol-formaldehyde (RF), most resorcinol cements

utilized today are PRF). They've been laid up to such an extent that the grain of all covers is principally corresponding to the longitudinal pivot. Covers are useful on the grounds that they consider the making of an assortment of shapes, including straight, rectangular, and bended cross-segments. Stuck overlaid lumber is utilized in both private and non-private designs. This investigation has effectively evaluated the strength and properties of glulam in a structure.

5.2 Conclusion

The study concludes that glulam as a product of timber is relevant in carving out architectural designs of buildings during its construction. It can also provide structural strength to the building and improves load bearing capacity.

These was further affirmed by the study findings in which 58.1% of the respondents believe that glulam has an acceptability on building designs and structures. Also 31.8% of the respondents revealed that glulam can enhance the initial stiffness while 61.8% revealed that glulam can enhance bending strength and load carrying capacity. Meanwhile 30.9% of the respondents strongly agreed that glulam is a structural material that improves the technical properties of a renewable raw material, wood., another 32.7% of the respondents have been using glulam for below 5 years, 29% have been using glulam for 5-10 years, while 38.1% have been using glulam for above 10 years. In addition 32.7% of the respondents strongly agree that glulam construction outperforms dimensional building in terms of strength and stiffness timber, and pound-for-pound, while 38.1% of the respondents agreed that architects and building engineers have virtually unlimited flexibility to design their own structural designs that include the use of glulam.

5.3 Recommendations

The following suggestions are made highlighted;

1. The use of glulam should be further explored for further purposes in construction and architectural designs.

2. Glulam should be encouraged in construction to ensure optimal functionality and enhance the design.

5.4 Contribution to knowledge

The use of glulam can contribute to the aid of academic knowledge, the survey conducted validate the hypothesis, showing that

- Design can be created through unlimited possibilities and flexibilities by creating structural designs with the use of glulam
- Glulam members have different conventional widths and lengths that can be custom-made to meet any design specifications.