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Characterization And Grading Of Timber Species Available In Nigeria For Structural Applications – A Systematic Review

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Abstract: *In Nigeria, a diverse range of timber species is available across different regions, many of which hold significant potential for structural applications in construction. However, the overdependence on a limited number of commercial timber species has led to overexploitation and market saturation, prompting a critical need to explore and characterize lesser-known species. This study presents a systematic literature review on the characterization and grading of Nigerian timber species for structural applications. The review assessed physical properties, including moisture content and density, as well as key mechanical parameters such as compressive strength, tensile strength, shear strength, modulus of elasticity (MOE), and modulus of rupture (MOR). The timber species reviewed were graded following the grading methodologies outlined in BS 5268-2 (2002), EN 384, and NCP 2 (1973). The results revealed significant variation in properties across species, with some lesser-used hardwoods like Irvingia gabonensis, Newbouldia laevis, and Brachystegia eurycoma demonstrating mechanical performance comparable to internationally accepted standards. While some indigenous species remain unclassified under existing standards, findings suggest the adoption of performance-based grading frameworks such as EN 338 to facilitate broader utilization. The study concludes that integrating international grading systems with indigenous practices will enhance the acceptance and structural use of underutilized timber species, promoting both economic development and environmental sustainability. Future research should focus on experimental testing and standardization of additional species to expand Nigeria's structural timber compilation.*
Keywords: *Timber Grading, Structural Applications, Nigerian Timber, Mechanical Properties.*

1. INTRODUCTION

The growing concerns over climate change, largely driven by industrialization and the excessive exploitation of natural resources, have led to a global shift towards more sustainable construction practices [1]. One key strategy in this regard is the promotion of renewable materials, particularly timber. Timber has long been recognized for its inherent advantages, including renewability, workability, high strength-to-weight ratio, and low embodied energy [2]. In this context, Nigeria, with its vast forest resources, is well-positioned to benefit from the responsible and efficient utilization of its indigenous timber species [3].

In recent years, the resurgence of interest in timber for structural applications has been driven by the need to reduce the environmental footprint of the built environment. As a natural and biodegradable material, timber is unique among structural materials due to its capacity for regeneration through sustainable forestry practices [4], [5]. Globally, forest areas cover approximately 4 billion hectares, with Nigeria accounting for about 96.2 million hectares [6]. This represents 10% of Nigeria's land area and contributes significantly to the global forest resource base [7]. If timber is properly utilized, it will contribute exceptionally to improving Nigeria's economic base and industrialization [8], [9].

The demand for timber in Nigeria is substantial, particularly due to its extensive application in the construction sector. The growing demand for timber and wood-based products has, however, led to overexploitation of commonly used species [10]. Globally, timber consumption is rising at an estimated annual rate of 1.7% [11], [12]. Despite this demand, existing forestry resources are insufficient to meet current needs, and market prices for high-grade timber continue to escalate. This has led to renewed interest in underutilized or lesser-known timber species as viable alternatives. Promoting the use of these lesser-known species could expand the supply base and enhance export potential [13].

However, a major barrier to the adoption of these alternative species is the lack of adequate information regarding their structural performance. The misuse and structural failure of timber have often been attributed to insufficient characterization and a lack of standardized grading data [7], [14]. For lesser-known timber species to gain broader acceptance, both locally and internationally, they must demonstrate strength, durability, and physical properties comparable to, or better than, conventional timber species [4]. Such parameters are critical in determining their suitability for structural applications.

Timber characterization and grading are crucial processes, as strength properties can vary significantly between species and even within a single species [15], [17]. Furthermore, different structural applications require timber of specific strength classes [18]. To address these variations, classification systems have been established to assign timber to appropriate strength classes. Therefore, structural grading plays a vital role in ensuring that timber products meet the required performance criteria, including structural integrity, strength, and durability [19]. Typically, grading involves assigning timber to stress grades based on shared mechanical properties.

Although several studies have investigated the mechanical characterization and grading of Nigerian timber species, comprehensive data on many newly explored species remain limited. Consequently, their use in structural applications remains limited. To address this gap, this paper presents a systematic literature review on the characterization and grading of timber species available in Nigeria. The aim is to encourage their efficient utilization in structural engineering applications and promote the sustainable use of local timber resources.

2. An Overview of the Criteria Used for the Grading of Timber Species

Various national and international codes of practice have been established to guide the grading of structural timber. In Nigeria, the National Code of Practice for the Structural Use of Timber [20] serves as the primary standard for grading timber for structural applications. Internationally, the widely adopted standards such as EN 338: Structural Timber – Strength Classes [21] and BS 5268-2: Structural Use of Timber for Permissible Stress Design [22] provide comprehensive frameworks for timber grading. These standards outline specific criteria for assigning timber species to appropriate strength classes based on mechanical properties and quality parameters. The grading principles and classification criteria as stipulated in [20], [21], and [22], respectively, are presented in the following sections:

A. The Nigerian Code of Practice (NCP 2: 1973)

The Nigerian Code of Practice for the Use of Timber in Building Construction, NCP 2:1973, was developed to guide the use of structural timber in Nigeria. It primarily adopts visual grading criteria based on features such as knot size, grain slope, wane, checks, and moisture content, but lacks numeric strength classifications according to international standards. The gradings are presented in Table 1.

[23] evaluated anatomical and strength properties of Nigerian-grown Triplochiton scleroxcylon and identified significant variability across samples, emphasizing the need for a more quantitative grading system. The study underscored the limitations of visual grading methods in reflecting true mechanical properties, especially in tropical hardwoods with high anatomical variability.

In light of these concerns, researchers have advocated for harmonization with strength-based grading standards such as EN 338 or BS 5268, which rely on direct mechanical testing rather than subjective visual indicators.

B. European Standard EN 338

The EN 338 standard provides a performance-based classification for structural timber, assigning strength classes based on characteristic values for modulus of elasticity (MOE), bending strength (MOR), and density. Softwoods are graded into classes. BS EN 338:2016 defines a total of 26 strength classes (C and D). The letters C and D refer to coniferous species (C classes) or deciduous species (D classes), and the number in each strength class refers to its characteristic bending strength in N/mm^2 [14].

Several studies have applied EN 338 to tropical hardwoods from Nigeria. [24] developed EN 338 strength grades for species such as *Afzelia africana* and *Gmelina arborea*, demonstrating that these timbers can meet international strength classes ranging from D30 to D50, with appropriate mechanical testing.

Similarly, [25] characterized *Terminalia ivorensis* grown in Nigeria and mapped its properties to the EN 338 framework. The study concluded that many Nigerian hardwoods possess the structural integrity to be classified under D24–D40 classes, affirming the suitability of EN 338 for tropical timbers.

Furthermore, [4] analyzed four underutilized Nigerian timber species and identified their respective EN 338 strength classes through experimental mechanical testing. This empirical approach yielded more reliable classifications than visual inspection, revealing that some lesser-known species rival commercially popular timbers in terms of strength and stiffness.

C. The British Standard BS 5268

The BS 5268 provides permissible stress design guidelines and strength classes for both softwoods and hardwoods. It incorporates both visual and mechanical grading methods and classifies the species based on density, modulus of rupture (MOR), and durability.

Although direct studies applying BS 5268 to Nigerian timber are limited compared to EN 338, international research supports its use for tropical species. For instance, [27] assessed the mechanical properties of *Triplochiton scleroxylon* (Ayous) from Cameroon and highlighted its potential fit within strength classes used in BS 5268. The

BS 5268 hybrid grading approach makes it adaptable for regions like Nigeria, where species often fail visual grading despite performing well mechanically. Its flexibility in accommodating both grading methods offers a practical solution for adopting indigenous timbers into structural applications.

The shift toward machine grading is widely adopted by Nigerian researchers, who argue that visual grading underrepresents the strength capacity of lesser-used species. [24] and [24] advocated for the adoption of EN 338 classifications in Nigeria, enabling standardized structural design and facilitating timber export. The summary of the strength classes of NPC 2: 1973, EN 338, and BS 5268 is presented in Table 1.

[23] and [25] stressed the need for the integration of international standards with indigenous knowledge by upgrading NCP 2:1973 could enhance timber quality assurance and expand the utilization of underexploited species.

The comparison between the three grading methods and grading classes are presented in Table 1.

Table 1. Comparison Between NCP 2: 1973, EN 338, AND BS 5268

Standard	**Grading Method**	**Strength Classes**	**Key Grading Criteria**
NCP 2:1973	Visual & Mechanical	N1, N2, N3, N4, N5, N6	Modulus of Elasticity (MOE), Modulus of Rupture (MOR), Compressive Strength, Visual Defects
BS 5268	Visual & Machine	Softwoods: C14–C50 Hardwoods: D30–D70	fmk (bending strength), ρk (density), Emean (modulus of elasticity), defects
EN 338	Machine	Softwoods: C14–C50 Hardwoods: D18–D70	fmk, ρk, Emean; based on statistical strength properties

3. RESULTS OF THE PREVIOUS RESEARCH EFFORTS

A. Physical Properties

Mosture Content

The moisture content of Nigerian timber species studied by previous research efforts is presented in Table 2. Moisture content (MC) significantly influences the dimensional stability and mechanical strength of timber.

The reviewed studies revealed wide variability in MC, ranging from 7.20% to 30.50%. The lowest moisture content of 7.20% was reported by [4] for *Guarea cedrata*, a hardwood species from Oyo State, indicating a high level of seasoning and likely good dimensional stability. In contrast, [5] recorded the highest MC of 30.50% for Phoenix dactylifera, a softwood from Kano State, suggesting a higher susceptibility to shrinkage and decay.

[14] reported relatively low MC values ranging from 7.36% to 14.29% for several hardwood species such as *Xylopia spp* and *Xanthothylum singleness* in Akwa Ibom State.

Similarly, [11] observed MC values between 13.71% and 24.28% across three species from Kwara and Ekiti States. The Species type, environmental conditions, and the time of harvesting likely influenced these variations in moisture content.

Density

The density of Nigerian timber species studied by previous research efforts is depicted in Table 2. Density is a critical parameter directly correlated with the strength of timber. Across the reviewed studies, density values ranged from 178.84 kg/m³ to 1148.2 kg/m³. Lowest density of 178.84 kg/m³ was reported for *Musanga cecropioides* by [17], indicating poor strength and limited suitability for structural use. On the other hand, [7] reported the highest density of 1148.2 kg/m³ for *Brachystegia eurycoma*, a hardwood from Kwara State, highlighting its potential for load-bearing applications.

Additional notable species include *Pseudocedrela kotschyi* (813 kg/m³) reported by [11], *Albizia zygia* (1108.7 kg/m³) documented by [7], and *Vitex doniana* (706 kg/m³) as studied by both [11] and [3]. These high-density hardwoods demonstrate favorable characteristics for structural timber classification.

Table 2. Physical Properties of Nigerian Timber Species

Authors	Timber Species	Common Name	Moisture Content (%)	Density Kg/m^3	Classification	Location
[17]	*Albizia Coriairia* *Anogeissus Leiocarpus* *Musanga Cecropioides*	Ayinre Orin dudu Aga	24.50 20.12 25.23	205.45 304.56 178.84	Softwood Softwood Softwood	Ogun State, Nigeria
[14]	*Stauditiastipitata* *Mitragyna spp* *Uapacaguineensis* *Xylopia spp* *Xanthothylon senegalenlensis*	Iyipokoyo Owen Mkpenek Atarabang Ata	12.5 8.33 14.13 14.29 7.36S	718 570 646 352 587	Hardwood Hardwood Hardwood Softwood Hardwood	Akwa Ibom State, Nigeria
[8]	*Irvingia Gaboneasis*	Bush Mango	13.95%	714.50	Hardwood	Kwara State, Nigeria
[16]	*Vitex doniana* *Ceiba pentandra* *Pseudocedrela kotschyi*	Eriri Somi Emi- gbegi	15.70 13.71 24.28	706 402 813	Hardwood Softwood Hardwood	Kwara State Ekiti State Kwara State
[12]	*Rhizophora racemosa* *Syzgium guineense*	Igba Adere	10.59 22.34	363 577	Softwood Hardwood	Kwara State, Nigeria
[7]	*Albizia zygia* *Brachystegia Eurycoma* *Funtumia Elastica*	Ayunre Eku Ire	12.47 11.78 12.71	1108.7 1148.2 389.13	Hardwood Hardwood Softwood	Kwara State, Nigeria
[6]	*Irvingia Gaboneasis* *Funtumia Elastica*	Bush Mango Ire	13.0 12.71	714.50 389.13	Hardwood Softwood	Kwara State, Nigeria
[10]	*Funtumia elastica* *Newbouldia laevis*	Ire Akoko	11.17 11.63	469.72 681.80	Hardwood Hardwood	Oyo State, Nigeria
[3]	*Vitex doniana*	Dinya	11.33	494.69	Hardwood	-

Authors	Timber Species	Common Name	Moisture Content (%)	Density Kg/m^3	Classification	Location
	Diospyros mespiliformis *Parkia biglobosa* *Isoberlinia doka*	Kanya Dorowa Doka	15.54 20.21 8.73	651.00 492.97 600.25	Hardwood Hardwood Hardwood	
[4]	*Brachystegia eurycoma* *Pterocarpus erinarceus* *Guarea cedrata* *Ricinodendron heudelotii*	Ako Ara Obobo Epuu	9.31 9.74 7.20 15.33	843 563 479 471	Hardwood Hardwood Hardwood Softwood	Oyo State, Nigeria
[5]	*Mangifera indica* *Terminalia catappa* *Phoenix dactylifera*	- - -	14.2 13.9 30.5	530 540 290	Hardwood Hardwood Softwood	Kano State, Nigeria

Hardwood and Softwood Classification

The classification of Nigerian timber species into either hardwood or softwood by previous research efforts is shown in Table 2. One of the basic parameters used for classifying timber is density. The reviewed studies broadly classified timber species as either hardwood or softwood, with hardwoods being predominant. Commonly reported hardwoods include *Vitex doniana*, *Albizia zygia, Guarea cedrata, and Irvingia gabonensis*, with densities above 600 kg/m^3 and moisture contents generally below 20%. Conversely, softwoods such as *Musanga cecropioides*, *Ceiba pentandra*, and *Phoenix dactylifera* were consistently found to have lower densities and higher moisture contents, rendering them less suitable for high-strength applications.

Interestingly, *Funtumia elastica* was inconsistently classified. While [7] classified it as a softwood based on a density of 389.13 kg/m^3, [10] and [6] categorized it as a hardwood. This implies that classification inconsistencies may arise due to ecological variability.

B. Mechanical Properties

Compressive Strength Parallel to Grain

The compressive strength of timber species reported by previous research efforts is presented in Table 3. The compressive strength parallel to the grain is a primary indicator of a timber's ability to resist axial compressive forces. The reviewed studies reported values ranging from 16.39 N/mm^2 to 84.43 N/mm^2. The highest compressive strength of 84.43 N/mm^2 was recorded for *Newbouldia laevis* by [10], followed by *Irvingia gabonensis* with 71.97 N/mm^2 as reported by [8] and [6]. Other notable values include 61.46 N/mm^2 for *Diospyros mespiliformis* [3], and 42.15 N/mm^2 for *Vitex doniana* [3]. On the lower end, *Rhizophora racemosa* (16.39 N/mm^2) and *Musanga cecropioides* (23.62 N/mm^2), reported by [12] and [15], respectively, exhibit relatively poor compressive performance

The impressive compressive strength result recorded for *Newbouldia laevis*, *Irvingia gabonensis*, and *Diospyros mespiliformis* could be attributed to their densities and lower moisture content as presented in Table 2. This implies their potential for structural applications. This is in concurrence with the findings of [27], who reported that density has a strong correlation with a variety of mechanical properties of timber species.

Tensile Strength Parallel to the Grain

Table 3 shows the tensile strength of Nigerian timber species reported in the literature. The tensile strength parallel to the grain reflects a timber's resistance to tensile forces along its length. The values ranged from 8.40 N/mm^2 to 85.97 N/mm^2. The highest tensile strength was reported for *Newbouldia laevis* that attained 85.97 N/mm^2 [4]. Similarly, *Albizia zygia, Brachystegia eurycoma and Irvingia gabonensis* demonstrated superior tensile strengths of 64.81 N/mm^2, 63.50 N/mm^2, and 62.39 N/mm^2 respectively [7] and [6]. In contrast, *Phoenix dactylifera* and *Rhizophora racemosa* exhibited much lower tensile strengths of 13.67 N/mm^2 and 8.40 N/mm^2, respectively [5] and [12].

Shear Strength

The shear strength values for timber species available in Nigeria is presented in Table 3. Shear strength values across species were generally moderate, with notable exceptions. *Newbouldia laevis* and *Funtumia elasticas* having the highest shear strength of 16.89 N/mm² and 11.26 N/mm² respectively [10]. *Isoberlinia doka* and *Parkia biglobosa* studied by [3] had shear strengths of 5.15 N/mm² and 6.10 N/mm², respectively, which fell within moderate ranges. In contrast, *Phoenix dactylifera* reported by [5] attained a shear strength of 2.44, exhibiting the lowest shear resistance. This indicates limited suitability for applications involving lateral forces or mechanical joints.

Modulus of Elasticity (MOE)

The result of the MOE of some selected timber species available in Nigeria is depicted in Table 3. MOE reflects the stiffness of a timber species, indicating its deflection response under stress. The highest values were observed in *Mangifera indica* (49,216.61 N/mm²) and *Terminalia catappa* (48,814.65 N/mm²), both studied by [5]. *Irvingia gabonensis* also displayed high MOE values of between 20,574.88 to 21,376.26 N/mm² as reported by [8] and [6]. Meanwhile, *Musanga cecropioides* and *Guarea cedrata* attained MOE of 4,190 N/mm² and 6,584.38 N/mm², respectively, as reported by [17] and [4], indicating the lowest stiffness. These findings have shown the potential of *Mangifera indica* and *Terminalia catappa* for use in structural elements requiring dimensional stability.

Modulus of Rupture (MOR)

The MOR values for the Nigerian timber species are presented in Table 3. The MOR represents the bending strength of a timber. The highest MOR of 190.40 N/mm² was recorded for *Irvingia gabonensis* by [6], followed by *Newbouldia laevis* having MOR of 143.28 N/mm² studied by [10] and *Parkia biglobosa* had MOR of 93.10 N/mm² as reported by [3]. Conversely, *Phoenix dactylifera*, and *Mangifera indica* attained MOR of 4.11 N/mm² and 12.35 N/mm² respectively [5], which were among the lowest. This discrepancy between high MOE and low MOR in *Phoenix dactylifera* highlights the need to assess both properties independently for bending applications.

Table 3. Mechanical Properties of Timber Species Available in Nigeria

Author (s)	Timber Species	Compressive Strength Parallel to grain (N/mm²)	Tensile Strength Parallel to Grain (N/mm²)	Shear Strength (N/mm²)	Modulus of Elasticity (N/mm²)	Modulus of Rupture (N/mm²)
[17]	*Albizia Coriairia*	25.67	22.78	4.0	5440	-
	Anogeissus Leiocarpus	28.10	27.81	4.0	6510	-
	Musanga Cecropioides	23.62	18.9	4.0	4190	-
[14]	*Stauditiastipitata*	40.13	53.84	-	13710	87.38
	Mitragyna spp	24.32	19.06	-	9470	36.55
	Uapacaguineensis	33.68	36.62	-	11950	64.91
	Xylopia spp	21.01	13.28	-	7320	28.20
	Xanthothylon senegalenlensis	27.96	24.18	-	10200	49.40
[8]	*Irvingia Gaboneasis*	71.97	62.39	4.48	20574.88	-
[11]	*Vitex doniana*	23.10	18.0	4.5	12134.30	30.098
	Ceiba pentandra	20.09	13.2	4.0	8853.71	21.985
	Pseudocedrela kotschyi	25.99	23.4	4.5	12185.45	39.415
[12]	*Rhizophora racemosa*	16.39	8.4	4.0	11517.91	14.0
	Syzgium guineense	21.28	15.0	4.0	11742.34	25.47

Author (s)	Timber Species	Compressive Strength Parallel to grain (N/mm^2)	Tensile Strength Parallel to Grain (N/mm^2)	Shear Strength (N/mm^2)	Modulus of Elasticity (N/mm^2)	Modulus of Rupture (N/mm^2)
[6]	*Irvingia Gaboneasis* *Funtumia Elastica*	71.97 20.01	62.39 59.20	4.48 3.69	21376.26 7536.42	190.40 60.33
[7]	*Albizia zygia* *Brachystegia Eurycoma* *Funtumia Elastica*	36.84 29.36 20.01	64.81 63.50 59.20	- - -	14224.65 11171.62 7536.42	93.23 59.18 60.33
[10]	*Funtumia elastica* *Newbouldia laevis*	41.93 84.43	45.40 85.97	11.26 16.89	10472.30 13778.30	75.10 143.28
[3]	*Vitex doniana* *Diospyros mespiliformis* *Parkia biglobosa* *Isoberlinia doka*	42.15 61.46 53.16 42.46	18.38 21.23 25.40 12.84	6.87 6.27 6.10 5.15	12,537.42 11,818.70 15,701.22 10,228.96	75.89 99.24 93.10 66.18
[4]	*Brachystegia eurycoma* *Pterocarpus erinarceus* *Guarea cedrata* *Ricinodendron heudelotii*	32.8 25.0 23.4 22.1	39.2 21.5 18.4 16.3	4.5 4.0 3.2 3.4	15947.81 9620.63 6584.38 9344.72	65.26 35.88 30.73 27.17
[5]	*Mangifera indica* *Terminalia catappa* *Phoenix dactylifera*	23.59 25.70 20.41	18.85 22.80 13.67	3.15 3.67 2.44	49216.61 48814.65 32744.25	12.35 12.25 4.11

4. Grading of Timber Species Available in Nigeria

Table 4 presents the Nigerian timber species graded following NCP 2: 1973, BS 5268, and EN 338 strength classes, alongside their recommended structural applications. The data was compiled from several studies and highlights both graded and ungraded species across these classification systems:

A. Ungraded Species

Several timber species, including *Albizia coriaria*, *Anogeissus leiocarpus*, and *Musanga cecropioides,* were not classified under any of the three grading systems. These species, though reported in literature by [7], have not yet been assigned to any recognized strength class, thereby limiting their use in structural applications. The absence of classification implies a lack of comprehensive testing or documentation according to established standards. Therefore, there is a need to carry out further research to grade these timber species.

Table 4. Grading of Nigerian Timber Species

Author(s)	Timber Species	NCP 2	BS 5268	EN 338	Recommended Application
[17]	*Albizia Coriairia* *Anogeissus Leiocarpus* *Musanga Cecropioides*	- - -	- - -	- - -	Not Graded Not Graded Not Graded
[14]	*Stauditiastipitata* *Mitragyna spp* *Uapacaguineensis* *Xylopia spp* *Xanthothylon senegalenlensis*	- - - - -	- - - - -	D45 D18 D35 C14 D24	Structural applications Non-load-bearing or lightly loaded structures Structural applications Lightweight apaplications Light to medium structural applications
[8]	*Irvingia Gaboneasis*	N1	D70	-	Structural applications
[11]	*Vitex doniana*	-	-	D30	Structural applications

Author(s)	Timber Species	NCP 2	BS 5268	EN 338	Recommended Application
	Ceiba pentandra *Pseudocedrela kotschyi*	- -	- -	C16 D35	Lightweight applications Structural applications
[12]	*Rhizophora racemosa* *Syzgium guineense*	- -	- -	C14 D24	Lightweight applications Light to medium structural applications
[6]	*Albizia zygia* *Brachystegia Eurycoma* *Funtumia Elastica*	N3 N6 N5	D50 D30 C14	D50 D30 C14	Structural applications Moderate structural applications Lightweight applications
[7]	*Irvingia Gaboneasis* *Funtumia Elastica*	N1 N5	D70 C14	- -	Load-bearing structures Lightweight applications
[10]	Funtumia elastica Newbouldia laevis	N4 N2	D18 D60	- -	Lightweight applications
[3]	*Vitex doniana* *Diospyros mespiliformis* *Parkia biglobosa* *Isoberlinia doka*	N4 N3 N4 N3	D30 D40 D40 D30	- - - -	Moderate structural applications Structural application Structural Applications Moderate structural applications
[4]	*Brachystegia eurycoma* *Pterocarpus erinarceus* *Guarea cedrata* *Ricinodendron heudelotii*	- - - -	- - - -	D50 D24 D18 D16	Structural applications Light to medium structural applications Non-load-bearing or lightly loaded structures Lightweight applications
[5]	*Mangifera indica* *Terminalia catappa* *Phoenix dactylifera*	N5 N5 N7	C30 D30 C14	- - -	Structural applications Moderate structural applications Lightweight applications

B. Grading in Accordance with BS 5268

i. *Irvingia gabonensis* was graded as D70 [8], [7] and *Newbouldia laevis* was graded as D60 [10]. These timber species are suitable for heavy structural applications.

ii. Medium grades like D35–D50 appear frequently for species such as *Pseudocedrela kotschyi*, *Isoberlinia doka*, *Diospyros mespiliformis*, and *Brachystegia eurycoma* as reported by [3], [4], and [11] respectively. These species are suitable for moderate structural applications.

iii. Lower strength classes (D14–D24) are attributed to species such as *Xylopia spp.*, *Xanthothylon senegalenlensis, Guarea cedrata*, and *Ricinodendron heudelotii* as reported by [4] and [14]. These species are recommended for non-load-bearing or lightweight structures.

The frequent assignment of D30 and D40 grades suggests a dominance of moderate-strength timber species within Nigeria's forest reserves.

C. Grading in Accordance with EN 338

Only a few species were classified under EN 338, reflecting limited regional adoption. Grades such as C14, C16, and C30 were observed for species like *Ceiba pentandra*, *Funtumia elastica*, and *Terminalia catappa* [5], [6], [11]. The C14 class, one of the lowest strength categories under EN 338, was the most frequent, indicating the prevalence of light-duty timber species in this context. This classification restricts usage to non-load-bearing applications, especially in lightweight or temporary structures.

D. Grading in Accordance with NCP 2 (1973)

The NCP 2: 1973 strength classes, N1 to N7 were used in the previous studies. Notably, *Irvingia gabonensis* consistently appears as N1, the highest class, aligning with its BS 5268 rating of D70. *Funtumia elastica* ranges from N2 to N5, reflecting variability in strength due to location, age, or testing method.

Mangifera indica, Phoenix dactylifera, and *Terminalia catappa* are typically assigned N5 to N7, suggesting lower structural performance.

5. CONCLUSION

This study confirms that several underutilized Nigerian timber species have the physical and mechanical properties suitable for structural applications. However, the existing Nigerian grading standard (NCP 2:1973) lacks the precision needed for reliable classification. International standards like BS 5268 and EN 338 offer more accurate, performance-based grading methods. Adopting these systems could improve timber utilization, promote sustainable forestry, and enhance the economic value of local species. To achieve this, more experimental data and standardized grading of additional species are essential.

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