OPEN ACCESS

Saudi Journal of Civil Engineering
Abbreviated Key Title: Saudi J Civ Eng
ISSN 2523-2657 (Print) |ISSN 2523-2231 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com/journal/sjce/home

Original Research Article

Reliability Assessment of Three Selected Timber Species Strength for Bridge Beams in Bending and Shearing Forces

Obianime, T. S[1*], Sule, S[1], Awodiji, C.T.G[1]

[1]Department of Civil and Environmental Engineering, University of Port Harcourt, P.M.B 5323, Port Harcourt, Rivers State, Nigeria

DOI: https://doi.org/10.36348/sjce.2025.v09i05.001 | **Received:** 02.03.2025 | **Accepted:** 08.04.2025 | **Published:** 05.05.2025

***Corresponding author:** Obianime, T. S
Department of Civil and Environmental Engineering, University of Port Harcourt, P.M.B 5323, Port Harcourt, Rivers State, Nigeria

Abstract

This study investigated the reliability of three timber species from the Niger Delta—Mansonia (*Mansonia altissima*), Ububa Red (*Berlinia grandiflora*), and Angala (*Rhizophora racemosa*) as bridge beams to Eurocode 5 design rules. The strength classes for Mansonia, Ububa Red and Angala timber species were established in accordance with the provisions of EN 338 (2009). The study classified Mansonia as D50, Ububa Red as D60 and Angala as D70 respectively. The limit state functions were developed considering the failure of the beams in bending and shear respectively. Reliability analysis was used to assess the structural performance of each timber species, and sensitivity analyses were conducted by varying design parameters to observe their effect on reliability indices. The reliability indices were computed using custom MATLAB programs based on the First Order Reliability Method. It was shown that the reliability indices generally decreased with increasing beam span and live load on beams for both bending and shear failure modes respectively. The timber beams showed the capacity to support live loads of 11.5 KN/m, 14 KN/m, and 16.5 KN/m over a 50-year reference period, meeting the target reliability index of 3.8 recommended by Eurocode 0 (1978). It is also found that the reliability of the beam increased with increase in depth and width of the beams. For this period, required beam depths were identified as 350 mm for Mansonia, 325 mm for Ububa Red, and 300 mm for Angala timber beam respectively. It is also found that Mansonia, Ububa Red and Angala timber beams are very safe for a span of 6.8m, 7.5m and 8m respectively. The Mansonia, Ububa Red and Angala timber beams are generally very safe in bending and shear.

Keywords: Limit State Functions, Bending, Shear, Reliability, Reliability Indices, Sensitivity Analyses.

Copyright © 2025 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution **4.0 International License (CC BY-NC 4.0)** which permits unrestricted use, distribution, and reproduction in any medium for non-commercial use provided the original author and source are credited.

INTRODUCTION

Timber is a versatile structural material in the world. The use of structural timber in civil engineering construction is as old as man. The goal of engineered construction is to create structures that optimize safety, cost-effectiveness, and functionality (Aguwaand Sadiku, 2012). In this regard, timber serves as a valuable resource due to its local availability, which provides opportunities to enhance local content in construction projects. By utilizing locally sourced timber, countries can reduce reliance on imported materials and stimulate the regional economy (Wilson *et al.*, 2021).

Reliability studies conducted on Nigerian-grown Abura timber by Aguwa (2013) have highlighted the suitability of this timber for construction purposes, emphasizing its uniformity across different regions of Nigeria. Jimoh and Aina (2017) found that timber properties are not consistent or predictable across different regions. These properties can vary depending on the species, the age of the timber, soil conditions, and environmental influences, making it necessary to conduct localized evaluations for specific uses.

According to Sule and Benu (2019), the safety factors aim to enhance the security of structural designs, but they do not guarantee absolute safety. These safety factors are often empirical, underscoring the importance of reliability analysis in timber construction. Reliability analysis provides a scientific approach to evaluating the performance and suitability of timber for various construction applications, offering a more precise understanding of its potential (Kapur and Pecht, 2014).

Structural reliability is defined as a measure of a structure's ability to perform without failure throughout its service life (Ranganathan, 1999). According to Ranganathan (1990), the primary goal of structural reliability is to establish design criteria and verification procedures that ensure a structure's performance meets the necessary safety and serviceability standards.

The variables influencing a structure's strength, stresses, and loads are considered random (Melchers, 2000). Therefore, the reliability of a structure is defined as the probability that its strength will exceed the maximum stress encountered during its lifetime (Kapur and Pecht, 2014).

Developing nations, including Nigeria, face escalating costs of traditional construction materials like steel and concrete, significantly impeding infrastructure development, particularly in rural and economically disadvantaged areas. Timber, being locally available, sustainable, and cost-effective, offers a practical alternative to address these challenges while fostering infrastructural growth (Aguwa, 2013; Sule and Benu, 2019).

The prohibitive cost of constructing steel and concrete bridges hasisolated most communities in the Niger delta. Utilizing locally sourced timber for structural components such as beams and decks could provide an affordable and sustainable solution to improve accessibility and stimulate economic activities (Wilson *et al*., 2020).

Despite the availability of Mansonia, Ububa Red and Angala timber species in the Niger Delta, their potential for critical structural applications remains largely untapped due to limited knowledge of their strength and reliability under load-bearing conditions. This underutilization highlights the need for targeted research to maximize their use in sustainable infrastructure development (Ayanlade, 2014; Owoeye *et al*., 2016).

In this study, the reliability analysis of Mansonia, Ububa Red and Angala timber bridge beams is carried out considering the failure of the beam in bending and shear respectively, based on First order reliability method developed MATLAB.

MATERIAL AND METHODS

Fully matured timber specimens of Mansonia, Ububa Red and Angala timber species were carefully sourced in their freshly felled (green) state. The Angala (Rhizophora racemosa) and Ububa Red (Berlinia grandiflora) samples were harvested from natural forest reserves in Obuama (Harry's Town), Degema Local Government Area, Rivers State, while the Mansonia (Mansonia altissima) samples were obtained from Ekese Town, Nembe Local Government Area, Bayelsa State. The lugs were cut into standardized dimensions of 350 mm x 350 mm x 3600 mm. Also, samples were taken from three distinct sections of each log: the top, middle, and base.

Preparation of Test Specimens

Test specimens were naturally seasoned for six months to achieve an equilibrium moisture condition at the Civil Engineering Laboratory of Rivers State University Nkpolu, Port-Harcourt, Rivers State. This natural seasoning method adhered to the specifications outlined by Aguwa (2010). Each lumber piece from the selected species was divided into three equal sections (top, middle, and bottom), and samples were taken from the inner, core, and outer layers of each segment. Timber samples measuring 20 mm × 20 mm × 380 mm were employed in a three-point bending test to evaluate the modulus of elasticity and static bending strength of the three selected timber species. For density testing, smaller samples measuring 20 mm x 20 mm x 60 mm were designated. For the moisture content evaluation, 20 mm x 20 mm x 20 mm, was used. Forty (40) samples were taken from each section (top, middle, and bottom) of the lumber for each selected timber species and used to carry out each test. These samples were used to determine the density in accordance with EN 13183-1 (2002) and EN 408 (2003). The three-point bending test was conducted following the specifications outlined in ASTM D193 (2000).The strength class of each selected timber specie (Mansonia, Ububa Red and Angala timber) were established (Obianime, 2025).

Dead and Traffic Loads on Mansonia, Ububa Red and Angala Timber Bridge Beams

The dead and traffic load on the beams wereesimated based on the specifications from BS 5400 (1978) as shown in Table 1.

Table 1: Design Data for Mansonia, Ububa Red Bridge and Angala Bridge beams

Variable	Value
Width of Bridge Carriageway (mm)	7000
Number of Notional Lanes	2
Width of Notional Lane (mm)	3500
HA Live Load on each Notional Lane (KN/m)	30
Uniformly Distributed Load due to HA Live Load (KN/m)	8.57
Knife Edge Load (KEL) at each Notional Lane (KN)	120
Uniformly Distributed Load due to KEL (KN/m)	34.28
Unit Weight of Mansonia (KN/m^3)	6.5
Unit Weight of Ububa Red (KN/m^3)	7.0

Variable	Value
Unit Weight of Angala (KN/m^3)	9.0
Span of Bridge Beam, L (mm)	6000
Depth of Bridge Beam (mm)	400
Spacing of Bridge Beam (mm)	375
Depth of Plank (mm)	75
Width of Plank (mm)	250
Width of Bridge Beam (mm)	150
Design Live Load on Beam (KN/m)	9.04
Design Dead Load of Mansonia Plank (KN/m)	0.14
Design Dead Load on Mansonia Beam (KN/m)	0.660
Design Dead Load of Ububa Red Plank (KN/m)	0.151
Design Dead Load on Ububa Red Beam (KN/m)	0.707
Design Dead Load on Angala Beam (KN/m)	0.194
Design Dead Load of Angala Plank (KN/m)	0.911
Spacing of Bridge Beams (mm)	375

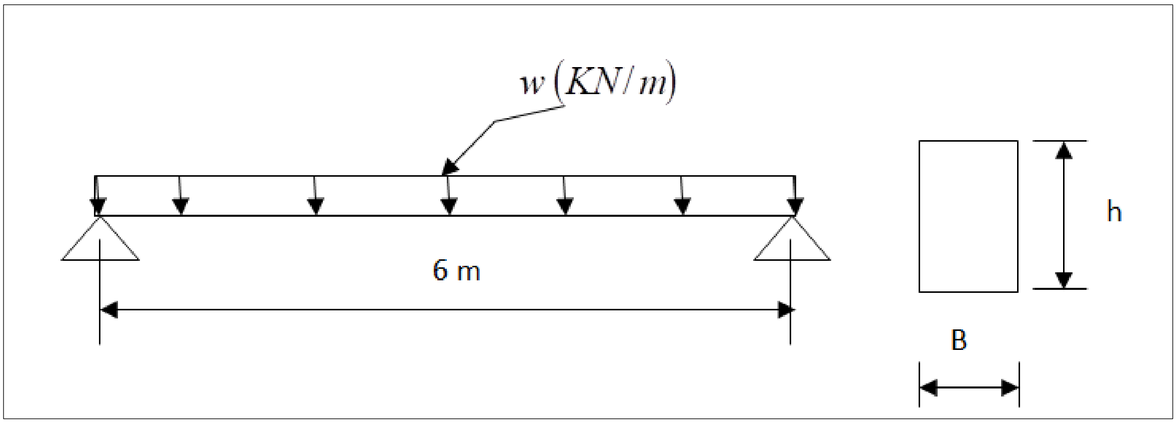

Figure 1: A simply Supported Solid Timber Bridge Beam under Uniform

Reliability Analysis of the three selected Timber Beams

The design criteria considered in this study are flexure and shear. The derivations of the limit state function are carried out in accordance with the Eurocode 5 (1995) design rules.

Bending Criterion

The limit state function *G(x)* for the bending criterion can be written as:

$$G(x) = \sigma_{perm} - \sigma_{app} \quad (1)$$

Where *G(x)* is the performance function that determines the safety state, σ_{perm} is the permissible bending stress, derived from the timber's characteristic bending strength and adjusted for safety factors, $\sigma_{app}$is the applied bending stress, calculated based on the external loads acting on the beam

According to Eurocode 5 (1995), the resistance of a timber beam in bendingis given by:

$$f_{m,d} = \frac{f_{m,k} \times k_{mod} \times k_{sys} \times k_h}{\gamma_m} \quad (2)$$

Where$f_{m,d}$is the design moment resistance (permissible stress),

$f_{m,k}$ = characteristic bending strength, Kmod= modification factor for duration of load and moisture content, k_{sys} = system strength factor (load sharing = 1.1), K_h = depth factor, γ_m is the partial safety factor for material properties usually taken as 1.3 for timber.

From strength of materials theory, the applied bending stress (σ_{app}) is given by:

$$\sigma_{app} = \frac{M_{Max}}{Z} \quad (3)$$

Where σ_{app} is the applied bending stress, M_{Max} is the maximum bending moment and *Z* is the sectional modulus.

The modulus of section of a solid rectangular timber section is given by:

$$Z = \frac{bh^2}{6} \quad (4)$$

Where b and *h* are the breadth and the depth of the timber cross-section

Applying Equation (4), Equation (3) becomes:

$$\sigma_{app} = \frac{6M_{max}}{bh^2} \quad (5)$$

The uniformly distributed load on beam is given by:

$$w = \gamma_g G_k + \gamma_q Q_k \quad (6)$$

Where $\gamma_g G_k$, $\gamma_q Q_k$ represents design dead and live load on bridge beam respectively

Let:

$$\gamma_g G_k = DL \quad (7)$$

And

$$\gamma_q Q_k = LL \quad (8)$$

Where $\gamma_g = 1.15$, $\gamma_q = 1.5$ represents partial safety factor for dead and live load on bridge respectively (BS 5400, Part 2 1978),

Applying Equation (7) and Equation (8) changes Equation (6) to:

$$w = DL + LL \quad (9)$$

Let:

$$\frac{DL}{LL} = \alpha \quad (10)$$

Applying Equation (10), Equation (9) becomes:

$$w = (\alpha + 1) * LL \quad (11)$$

For a simply supported beam under uniform loading, the maximum bending moment is
given by:

$$M_{\max} = 0.125wL^2 \quad (12)$$

Applying Equation (11), Equation (12) becomes:

$$M_{\max} = 0.125(\alpha + 1) * LL * L^2 \quad (13)$$

Substituting for M_{Max} in Equation (5) using Equation (13) changes Equation (5)
to:

$$\sigma_{app} = \frac{0.75(\alpha+1)*LL*L^2}{bh^2} \quad (14)$$

Application of Equation (2) and Equation (14) gives the limit state equation in bending as:

$$G(x) = \frac{f_{m,k} \times k_{mod} \times k_{sys} \times k_h}{\gamma_m} - \frac{0.75(\alpha+1)*LL*L^2}{bh^2} \quad (15)$$

Shear Criterion

For a simple beam under uniform loading, the maximum shear force is given by:

$$V_{\max} = 0.5wL \quad (16)$$

The applied shear stress of a solid timber beam is given by:

$$S = \sigma_v = \frac{1.5V_{max}}{bh} = \frac{0.75(\alpha+1)*LL*L}{bh} \quad (17)$$

According to Eurocode 5 (1995), the shear strengthof a timber beam parallel to grain of the
beam is given by:

$$R = f_{v,g} = \frac{f_{v,k} \times k_{mod} \times k_{sys}}{\gamma_m} \quad (18)$$

Where $f_{v,k}$ is the characteristic shear stress

Applying Equation (17) and Equation (18), the limit state equation in shear becomes:

$$G(x) = \frac{f_{v,k} \times k_{mod} \times k_{sys}}{\gamma_m} - \frac{0.75(\alpha+1)*LL*L}{bh} \quad (19)$$

First Order Reliability Method

The First Order Reliability Method (FORM) is used to calculate the reliability indices corresponding to the performance function in bending and shear.

The performance function, $G(X)$ of a structure at a limit state is usually a function of the basic variables. Mathematically, the performance function $G(X) > 0$ represents safe domain, $G(X) = 0$ represents limit state surface and $G(X) < 0$ represents failure domain.

Let the limit state function in the space of input variables $X_1, X_2, ..., X_n$ be given by:

$$G(X_1, X_2 \ldots \ldots, X_n) = 0 \quad (20)$$

The normal random variables X_i are transformed into independent normal variables using the transformation:

$$Z_i = \frac{X_i - \mu_{xi}}{\sigma_{xi}}, \ (i = 1, 2, \ldots.., n) \quad (21)$$

Where Z_i = standardized independent normal variable with mean of 0 and standard deviation of 1, X_i = the original normal random variable to be transformed, μ_{xi} = the mean of the original random variable X_i, σ_{xi} = the standard deviation of the original random variable X_i.

Using Equation (21), the limit state equation for n transformed normal variables is given by:

$$g(\sigma_{x1} * Z_1 + \mu_{x1}, \sigma_{x2} * Z_2 + \mu_{x2}, \sigma_{x3} * Z_3 + \mu_{x3}, \ldots\ldots\ldots, \sigma_{xn} * Z_n + \mu_{xn}) = 0 \quad (22)$$

For non-normal variables, each statistically independent non-normal variable is considered individually and is equated with an equivalent normal variable at the design point to yield:

$$\Phi\left(\frac{x_i - \mu_{xi}^N}{\sigma_{xi}^N}\right) = Fx_i(x_i) \quad (23)$$

where $\Phi(\cdot)$ = cumulative distribution function of the standard normal variable at the design point; $\mu_{xi}^N, \sigma_{xi}^N$ represents the mean and standard deviation of the equivalent normal variable at the design point respectively; $Fx_i(x_i)$ = cumulative distribution function of the original non-normal variables.

The mean of the equivalent normal variable at the design point is given by:

$$\mu_{xi}^N = X_i - \Phi^{-1}[F_{xi}(X_i)\sigma_{xi}^N] \quad (24)$$

Equating the probability distribution functions of the original variable and the equivalent normal variable at the design point yields:

$$\frac{\Phi}{\sigma_{xi}^N}\left(\frac{x_i - \mu_{xi}^N}{\sigma_{xi}^N}\right) = fx_i(x_i) \quad (25)$$

Where $\phi(\cdot)$ and $fx_i(x_i)$ = probability distribution function of the equivalent standard normal and the original non-normal random variable respectively.

$$\Phi^{-1} = [F_{xi}(X_i)]\sigma_{xi}^N = x_i - \mu_{xi}^N \quad (26)$$

Application of Equations(25) and (26) yields the standard deviation of the equivalent normal variables as:

$$\sigma_{xi}^N = \emptyset \frac{(\Phi^{-1}[F_{xi}(X_i)])}{fx_i(x_i)} \quad (27)$$

The design points on the failure surface that minimize the distance from the origin to the failure surface are obtained by optimization.

The statistics of the basic random variables are presented Table 2.

Table 2: Statistics of the Basic Random Variables

Variable	Probability Distribution	Mean	Standard Deviation	Coefficient of Variation
Bending Strength Parallel to Grain, $f_{m,k}$ (N/mm^2)	Lognormal	50,60,70	2.05, 1.62, 1.47	0.027
Design Live Load on Beam, LL (KN/m)	Gumbel	9.04	2.26	0.25
Design Dead Load on Bridge Beam, $G_{,k}$ (KN/m)	Normal	0.66, 0.707, 0.911	0.04242	0.06
Width of Bridge Beam, B (mm)	Normal	150	9	0.06
Depth of Bridge Beam, H (mm)	Normal	400	24	0.06
Span of Beam, L (mm)	Normal	6000	18	0.03
Dead-Live Load Ratio, Live Load, α	Deterministic	-	-	-
Unit Weight, γ_w (KN/m^3)	Normal	6.5,7.0,9	0.238	0.034
Load Duration Factor, K_{mod}	Lognormal	0.9	0.135	0.15
Partial Safety Factor for Material, γ_M	Normal	1.3	0.078	0.06
Load Sharing Factor, K_{sys}	Lognormal	1.1	0.165	0.15
Spacing of Bridge Beam, sb (mm)	Normal	375	225	0.06
Shear Strength Parallel to Grain, f_{vg} (N/mm^2)	Lognormal	4.6, 5.3, 6.0	0.795	0.15

Results of Reliability Analysis

The results of the reliability analysis of Mansonia, Ububa Red and Angala timber bridge beams based on First Order Reliability Method coded in MATLAB language considering the failure of the beams ion bending and shear are presented in Figures 1 to Figure 8 respectively.

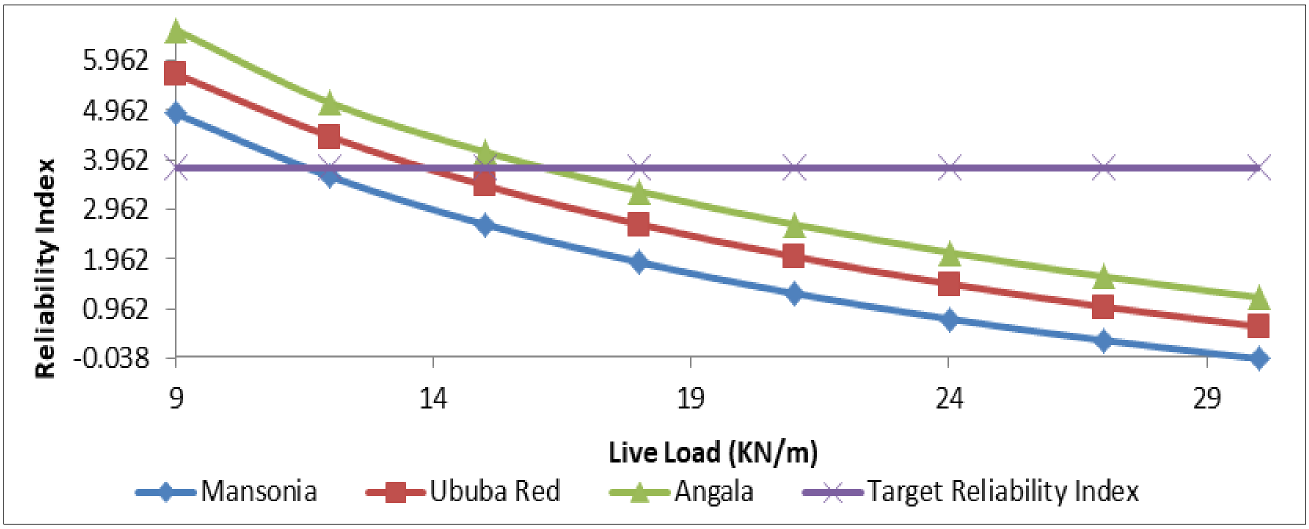

Figure 1: Relationship between Reliability Index and Live Load on Beams (Bending Failure Mode)

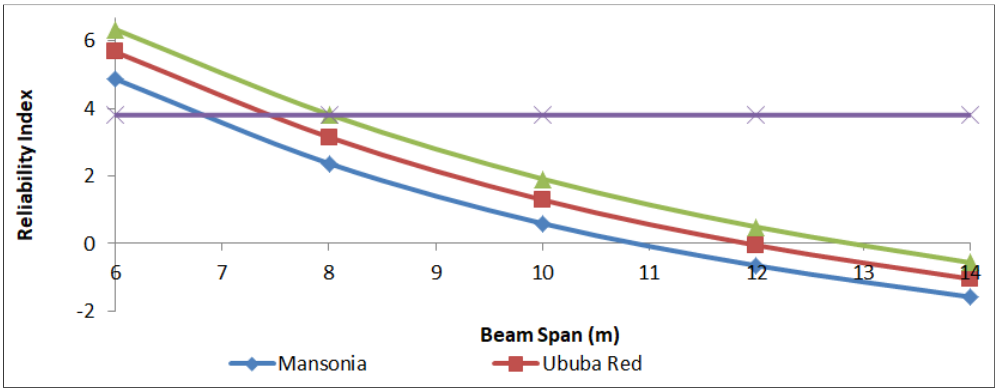

Figure 2: Relationship between Reliability Index and Beam Span (Bending Failure Mode)

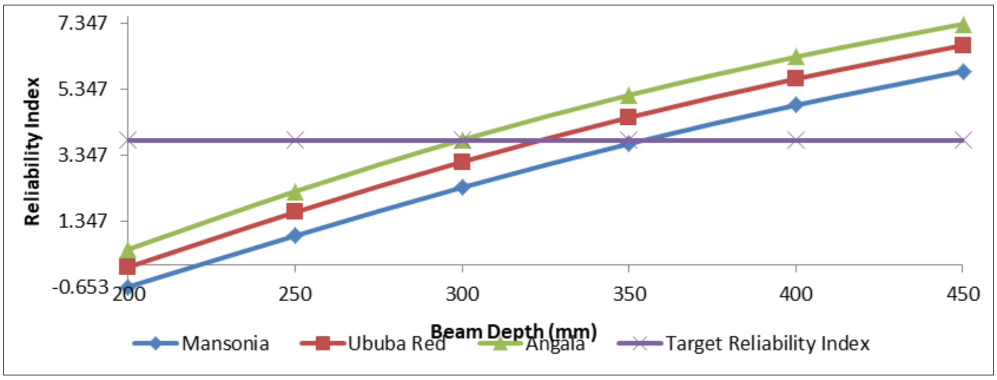

Figure 3: Relationship between Reliability Index and Beam Depth (Bending Failure Mode)

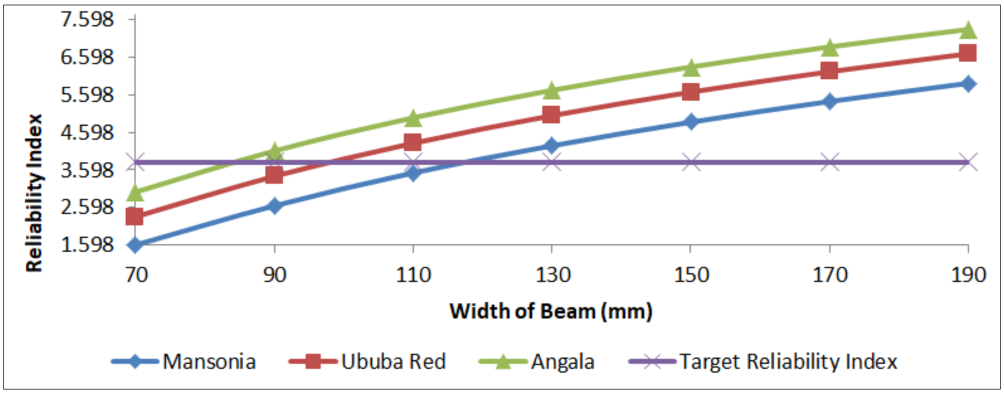

Figure 4: Relationship between Reliability Index and Beam Width (Bending Failure Mode)

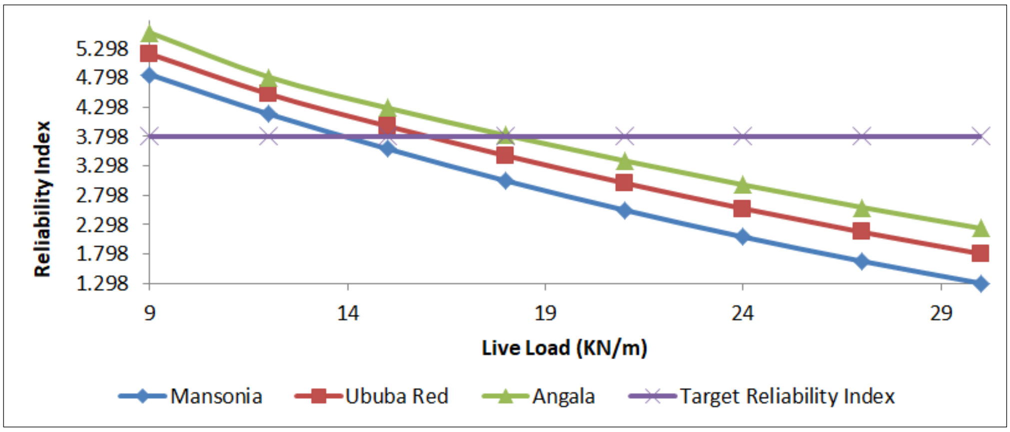

Figure 5: Relationship between Reliability Index and Live Load (Shear Failure Mode)

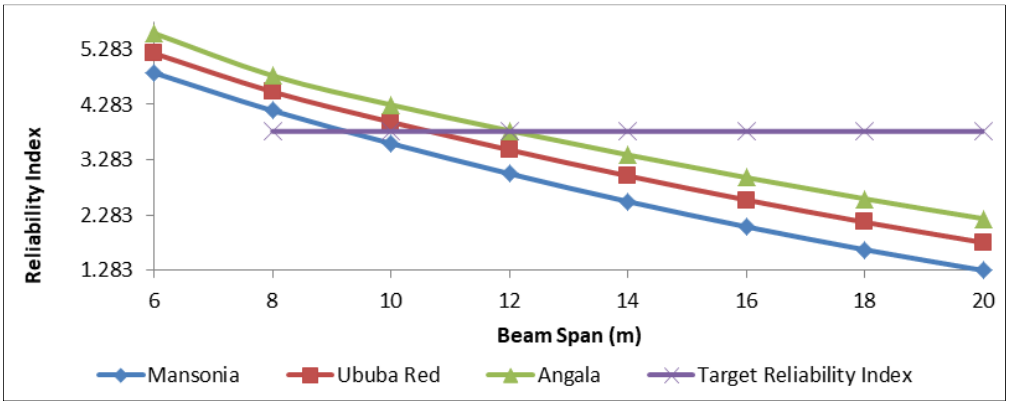

Figure 6: Relationship between Reliability Index and Beam Span (Shear Failure Mode)

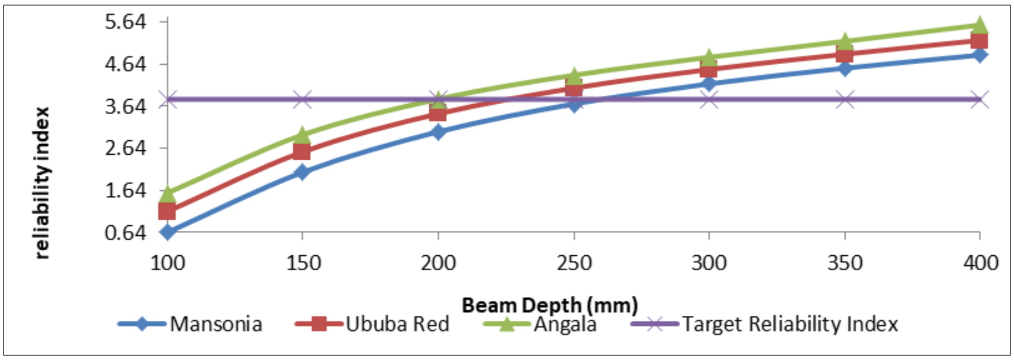

Figure 7: Relationship between Reliability Index and Beam Depth (Shear Failure Mode)

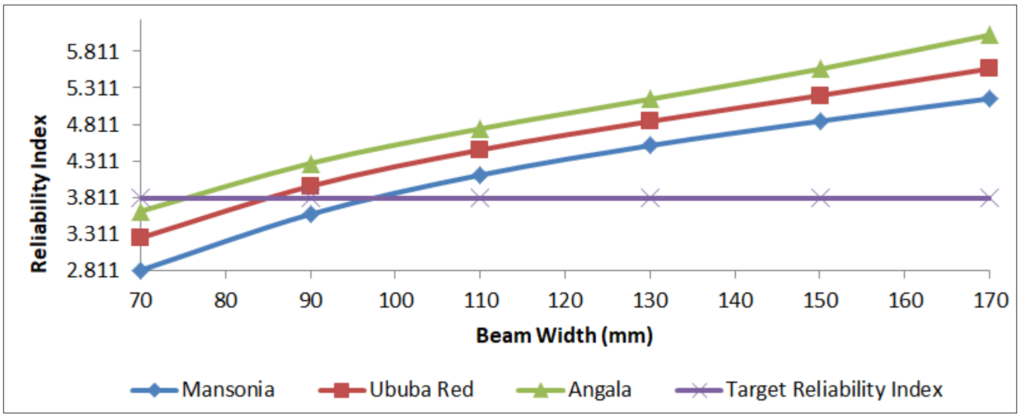

Figure 8: Relationship between Reliability Index and Beam Width (Shear Failure Mode)

Performance of the Beamsin Bending

In bending, the reliability of beams decreases with an increase in live loads. This reduction is attributed to amplified bending moments under higher live loads, leading to lower reliability indices. This is in agreement with the findings of Aguwa (2014) and Owoeye *et al*., (2016), who noted that increased live loads adversely affect the bending performance of timber bridge beams due to intensified stress levels. Despite this, Mansonia, Ububa Red, and Angala timber beams meet the target reliability index of 3.8 for a 50-year reference period under live loads of 14 KN/m, 16.5 KN/m, and 18 KN/m, respectively.

In shear, the reliability indices also decline as live loads increase. Amplified bending moments from higher loads result in greater shear stresses, reducing the reliability index. These observations align with the findings of Wilson *et al*., (2020) and Derikvand *et al*., (2019), who emphasized the adverse effects of increased loading conditions on the shear reliability of timber structures.

Performance of the Beams in Shear

Figure 5 to Figure 8 show the relationship between live load and reliability index for the shear failure criterion. As live loads increase, shear stresses intensify, leading to a reduction in reliability indices. The maximum live load limits for achieving the target reliability index of 3.8 are 14 KN/m for Mansonia, 16.5 KN/m for Ububa Red, and 18 KN/m for Angala. These findings align with observations by Aguwa (2014), which highlighted that increasing live loads adversely affect shear reliability in timber structures. Longer spans increase shear stresses, resulting in lower reliability indices. Safe span limits to meet the target reliability index are 9 m for Mansonia, 11 m for Ububa Red, and 12 m for Angala. Similar results were reported by Wilson *et al*., (2020), emphasizing the significance of span optimization in maintaining shear performance for timber beams. Increased beam depth enhances load-bearing capacity, thereby improving reliability. To meet the target reliability index, the required beam depths are 250 mm for Mansonia, 225 mm for Ububa Red, and 200 mm for Angala. Similarly, wider beams improve shear performance, with the required widths being 100 mm for Mansonia, 86 mm for Ububa Red, and 75 mm for Angala. These findings corroborate the conclusions of Derikvand *et al.*, (2019), which highlighted the role of increased beam dimensions in enhancing the reliability of timber structures under shear.

CONCLUSIONS

Based on the findings of this study, the following conclusions can be made:

i. The reliability indices generally decreased with increasing live load and beam spanparticularly considering failure of the beams in bending and shearrespectively.
ii. For the bending failure mode, the bridge beams made from Mansonia, Ububa Red, and Angala can support live loads of 11.5 kN/m, 14 kN/m, and 16.5 kN/m, respectively, meeting the target reliability index of 3.8 for a fifty-year reference period as recommended by Eurocode 0 (1978).
iii. The reliability index of the beams increased with larger beam widths and depths.
iv. The required beam depths corresponding to fifty years reference period are 350 mm for Mansonia, 325 mm for Ububa Red, and 300 mm for Angala, considering bending failure.

REFERENCES

- Aguwa, J.I. and Sadiku, S. (2012). Structural Reliability Analysis on the Nigeria Ekkitimber bridge beam subjected to shearing force under Ultimate limit state. *Research Journal in Engineering and Applied Sciences, 1*(4): 240-246.
- ASTM D193 (2000). Standard Method of Testing Small Clear Specimens of Timber, American Society of Testing and Materials, USA. Characteristics of Timber – Relationship to Properties.
- Ayanlade, A. (2014) Remote Sensing of Environmental Change in the Niger Delta, Nigeria. PhD thesis submitted to Department of Geography, School of Social Sciences and Public Policy, King's College London, University of London.
- BS 5400, Steel, Concrete and Composite Bridges Part 2 (1978). Specifications for loads. British Standard Institutions, London.
- BS EN 338 (2003), Structural timber-Strength classes. European committee for standardization, CEN, 2009, Brussels, Belgium
- Derikvand, M., Hedayatnia, H., & Ghalehnovi, A. (2019). Effect of cross-sectional dimensions on the structural reliability of plantation timber. *Wood Science and Technology, 53*(2), 205-220.
- EN 13183-1 (2002). Moisture Content of a Piece Of Sawn Timber. Determination by Oven-Dry Method. European Committee for Standardization, CEN Brussels, Belgium.
- EN 408 (2003). Timber Structures. Structural Timber and Glued Laminated Timber. Determination of some Physical and Mechanical Properties. European Committee for Standardization, CEN Brussels, Belgium.
- Eurocode 5. Design of timber structures part 1.1. General rules and rules for buildings. Publication of European Committee for Standardization, 1995.
- Jimoh A. A. and Aina S. T. (2017). Characterisation and Grading of Two Selected Timber Species grown in Kwara State Nigeria. Nigerian Journal of Technology, (36)4: 1002-1009.
- Kapur, K. C. and Pecht, M. (2014). Reliability Engineering, First Edition. John Wiley and Sons, Inc.
- Melchers, R. E. (1999). Structural Reliability: Analysis and Prediction. John Wiley and Sons.
- Obianime, T.S. (2025). Strength Classification and Reliability assessment of three selected Timber species as bridge Beams in the Niger Delta. Unpublished PhD Thesis for the award of PhD in Civil Engineering Department, University of Port Harcourt, Rivers State, Nigeria.
- Owoeye, T., Ayeni, O., & Dada, A. (2016). Reliability assessment of Nigerian timber species for bridge deck applications. *Journal of Sustainable Construction Materials, 4*(4), 72-80.
- Ranganathan, R. Structural Reliability, Analysis and Design, Jaico Publishing House, Mumbai, 1990.
- Sule, S. and Benu, M.J. Reliability Analysis of a Solid Timber Column Subjected to Axial and Lateral loading. FUOYE Journal of Engineering and Technology, 4 (2), pp. 1-5, 2019.
- Wilson, M. J., Adebayo, T. O., & Sule, S. O. (2020). Structural performance of African birch timber under compressive and shear forces. *Journal of Engineering and Applied Sciences, 15*(5), 88-96.

© 2025 | Published by Scholars Middle East Publishers, Dubai, United Arab Emirates