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STOCHASTIC ASSESSMENT OF NIGERIAN WOOD FOR BRIDGE DECKS

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ABSTRACT
This presentation assures the suitability of Nigerian wood using a stochastic safety evaluation method for bridge decks. A timber bridge deck is modeled in accordance to current specifications, to represent real life experiment in order to depict the structural behavior of planks when used as bridge decks. This model is then subjected to some degree of entropy using Advance Second Moment Reliability Assessment (ASMRA) method, which is then subsequently analyzed using JAVA library with the help of Flanagan polynomial. It is observed that, strength classes, timber thicknesses and stringer spacings are the major factors among others influencing the structural behavior of Nigerian timber species proposed as bridge decks material. Therefore, the major classes of the timber recommended for bridge decks are those within the strength classes N_1 to $N_4$and with dimensions ranging from 100 x 250mm to 150 x 300mm on stringers spaced not greater than 300mm. These strength classes with their corresponding material properties can be a source of sustainable bridge decks material over a reasonable period of time as indicated by the probability of failure as a result of damage due to load accumulation. In view of this, timber which is a locally available material can be used as supplement for bridge decks to substitute for the expensive concrete and steel which are the most commonly used materials and substantially reduce the cost of decks. Also, abandoned bridges with defects only in their decks in both rural and urban locations can be effectively rehabilitated in order to improve traffic flow, economic activities and the quality of life of the people.

Keywords*: Nigerian timber classifications, sizes and spacing, bridge decks, safety and Flanagan polynomial.*

1. INTRODUCTION
The need for local content in the construction of engineering infrastructure is now a serious engineering challenge in Nigeria. This is because vast quantities of local raw materials, which must be processed and used for cost effective construction abound. Construction activities based on these locally available raw materials are major steps towards industrialization and economic independence for developing countries [1]. Wood is one of the naturally occurring raw materials which abound in Nigeria and it had been put to use as a building material for construction since prehistoric times. It is available in large quantities in the forested parts of the country [2].
It has been described [3] that timber is a low density, cellular, polymeric composite which does not fall into any one class of materials; rather it tends to overlap a number of classes and as a result of its high strength performance and low cost, timber was found to be the world most successful fiber composite. Thus with critical analysis of our environment and careful exploration of the structural properties of timber, one can adequately establish and design an environmentally friendly structure which is cost effective.
Reinforced concrete and steel which has edged out timber as a construction component for bridges was reported [4]as not been an everlasting material they were assumed to be. This according to him is because many countries have experienced serious problems with concrete bridges built that are between forty and fifty years old. This was backed with the assertions stated in VERMONT[5] local road fact sheet. It was clearly stated in this local fact sheet that, properly treated, timber is stable and durable under the most severe weather and site conditions, which is one of its attractive performance features for bridges as it is completely resistant to the deicing salts, decay and insect attacks. It had also been noticed[4], that deicing salts have caused significant and surprisingly rapid deterioration of both steel and concrete bridges and

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components. Also when a larger structural timber is exposed to fire, there is some delay as it chars and eventually flames.

Treated timber bridge decks are built in days not weeks, because materials are low energy, certified, reusable and renewable, where components are shop manufactured under controlled conditions to maintain quality [6]. Due to the current dispensation and increased challenges in global development in all sectors of the economy, there exist these motives to build bridges faster that will last longer, for less money and with aesthetics appeal which has led to the quest for the perfect bridge material.

Currently, the use of timber as a bridge deck or bridge component has not been a common practice in Africa, although there are a few physical examples associated with scarce historical documentation in the forested areas of the country and Africa. This study of using timber for bridges brings to focus current reasoning and the integration of advanced technologies to suit the available climatic, natural and human resources to solve the problem of transportation, by making cheaper, better and more reliable structural systems in highways [7].

The use of this renewable composite and lightweight natural resource as a bridge deck, will not only be a new strategy for development in the third world and tropics but also as a sustainable development which will help to overcome the exclusion of timber technology in modern time, thereby strengthening its inclusion through research and practical applications.

It is in this regard that this study assesses the possibility of employing various Nigerian timber species as innovative, sustainable and cost-effective materials for bridge decks and also evaluate the long-term performance and economic viability of Nigerian timber for rehabilitating abandoned bridges in order to open up old roads in urban and rural areasso as to promote interest in the use of wood as a competitive bridge construction material by adding value to the use of local resources forthe bridge construction industries.

2. STUDY METHODOLOGY

The concept of Advance Second Moment Reliability Assessment (ASMRA) method is used herein to evaluate the structural safety of various Nigerian timber species for bridge decks. This is because, there is need for a fully probabilistic approach to the safety assessment of structural timber decks, due tomany factors, such as climate, material composition and degradation of structural timber, occurrence of natural disasters and impacts of man-made technology control the existence of human beings and the quality of the surrounding environment of bridge decks[8]. Many of these quantities cannot be represented adequately by deterministic values or relationships, thus, the variability in these quantities need be included in models of both nature and the built environment [8, 9].

With adequate Probability Density Functions (PDF) to represent the possible variability of each individual random variable, the combined effect of these variables on the performance function of a bridge can be used to study the safety or possibility of using Nigerian timbers for bridge decks. The reliability which can be seen as the detection of rare physical events such as failures, which usually occur with low probability, play key roles in the probabilistic safety assessment of engineering structures [10].

2.1 Plank Deck Structural Design Model

A typical plank or timber deck consists of planks placed on stringers as shown in Figures 1 and 2, according to Nowak and Saraf [11]. There are two categories of plank decks depending on the direction of planks versus the direction of traffic: transverse deck and longitudinal decks. For a typical transverse plank deck the span of the deck is perpendicular to the direction of traffic.

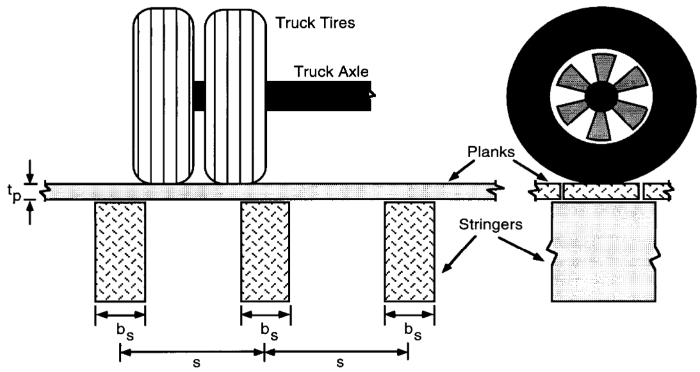

Figure 1 - Typical Transverse Plank Deck (Nowak and Saraf [11]).

A longitudinal plank deck, as shown in Figure 2, is placed parallel to the direction of traffic. It is assumed that stringers have an adequate load carrying capacity and that they provide a sufficient support for planks.

With reference to the American code [12], performance function for safety evaluationis developed as:

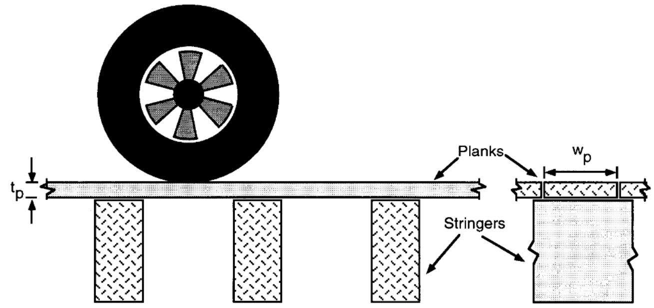

Figure 2 - Typical Longitudinal Plank Deck (Nowak and Saraf [11]).

$$f(x_1, x_2, , , x_n) = 0.2667 f_{bo} w_p t_p^2 C_d - 0.15625 \rho_p w_p t_p s^2 - 0.1875 \rho_s w_p t_s s^2 - 0.21875\{P(2s - b_t) + w_l s^2\} \quad (1)$$

Equation (1) is for plank decks under flexure, where the depth of the flexural component does not exceed its width, or where lateral movement of the compression zone is prevented and where points of bearing have lateral support to prevent rotation. As a result of this, the structural performance of the plank deck is determined by loads and resistances.

3. DAMAGE ACCUMULATION MODEL

The damage accumulation model is used to mathematically describe the long term strength reduction as a function of stress level and duration of loading. Thus, the concept of Gerhards[13] model is adopted. Gerhards[13]opined that the rate of damage accumulation is exponentially dependent on stress level. A simple arithmetic solution to Gerhards[13] model has been given by Hoffmeyer[14], after testing hundreds of timber species with different construction sizes and various moisture contents. For timber decks, the working condition was assumed to be within the range of 11 - 20% moisture content. Therefore, the damage accumulation model was developed to be;

$$f(x_1, x_2, , , x_n) = 88.5 - 7.85\, log_{10}\, t_f - 4901.960784 \frac{p(t)}{f_b} \quad (2)$$

This defines the possible time to failure for timber under the influence of load accumulation effect over time. Equation (2) will be used to assess the structural safety of the system under bridge load decks and stress level at a predictable time to failure (for instance, 50 years) in order to check the long term viability and economic performance of employing Nigerian timber for bridge decks. According to Melchers [15] the target reliability (β) for timber members ranges from 2.0 to 3.0 with strong mean of 2.5. A target structural safety or reliability index of 2.5 was set to assess and predict the behavior of Nigerian timber when used as bridge deck under specific design conditions of loading and geometrical properties in accordance to the American code [12] specifications.

3.1 Data Source

Table 1 gives the detail of material quality for the timber species proposed for bridge decks. Note that μ is the mean of the variable data and σ the standard deviation of the variables. Table 2 shows the stochastic and other suggested parameters for the timber materials evaluation.

4. ANALYSIS AND RESULTS

4.1 General structural reliability assessment

The general structural reliability assessment of using four Nigerian timbers (namely EKKI, APA, IROKO and ABURA) for bridge decks was executed in relation to Equation (1) by ASMRA method using JAVA library with the help of Flanagan polynomial. The results obtained are displayed in Table 3.The safety index, β, is as obtained from the execution of ASMRA while employing Equation (1).

Table 1 –Dry Grade (80%) Stress

Source and Names of Wood			Flexural Strength,f_{bo} (Grade 80) kN/m^2		Unit Weight,ρ_t (kN/m^3)		Strength Group	Durability
			Lognormal		Normal			
Data Source	Botanical Name	Standard Name	μ	σ	μ	σ		
Aguwa&Sadiku [1]	Lophiraalata	Ekki	29960	3295.6	11.33	0.6798	N_1	Very Durable
Aguwa [7]	Afzeliabipindensis	Apa	23940	3112.2	7.98	0.8778	N_2	Very Durable
CIRAD [16]	Chlorophoraexceisa	Iroko	18507	2525.5	6.40	0.6000	N_3	Very Durable
CIRAD [17]	Mitragynaciliata	Abura	14478	2375.9	6.00	0.500	N_4	Non-Durable

Table 2 - Other Design Data

Source	Data	Value			Distribution Type
		μ	COV (%)	σ	
Nowak and Saraf[10]	Width of timber	250-300mm	12	30.00	Lognormal
Nowak and Saraf[10]	Timber thickness	100mm	7	7.00	Lognormal
Nowak and Saraf [11]	Stringer spacing	300-600mm	23.33	70.00	Lognormal
AAHSTO LRFD [12]	Unit weight of surfacing material	22.426 kN/m^3	24.53	5.5	Normal
AAHSTO LRFD [12]	Surfacing thickness	70mm	14.98	10.00	Normal
AAHSTO LRFD [12]	Wheel load	70 kN	14	9.8	Lognormal

Table 3– Reliability of Nigeria timber (Ekki, Apa, Iroko And Abura).

β	f_{bo}	w_t	t_t	ρ_t	S	ρ_s	t_s	P
				EKKI				
4.51619	29960	0.25	0.1	11.33	0.3	22.426	0.07	70
3.97876	22759.1651	0.17860	0.08070998	11.3301	0.41087	22.4329	0.07000	70.9440
3.86841	24825.3080	0.20184	0.08539701	11.3302	0.49374	22.4399	0.07001	70.9734
3.85186	25186.4961	0.20446	0.08669217	11.3303	0.51219	22.4459	0.07002	70.7435
3.84950	25244.1376	0.20505	0.08685331	11.3304	0.51517	22.4518	0.07002	70.7003
3.84916	25252.7246	0.20511	0.08688318	11.3305	0.51561	22.4576	0.07003	70.6935
3.84911	25253.9364	0.20512	0.08688663	11.3306	0.51568	22.4634	0.07004	70.6925
3.84910	25254.1332	0.20512	0.08688730	11.3307	0.51569	22.4692	0.07004	70.6923
3.84910	25254.1584	0.20512	0.08688737	11.3308	0.51569	22.4750	0.07005	70.6923
3.8491	25254.1636	0.20512	0.08688739	11.331	0.51569	22.4808	0.07005	70.6923
				APA				
3.66764	23940	0.25	0.1	7.98	0.3	22.426	0.07	70
3.25391	17872.6451	0.19597	0.08546123	7.98019	0.40362	22.4325	0.07000	70.8454
3.19515	19832.8101	0.21171	0.08873686	7.98038	0.46550	22.4387	0.07001	70.7947
3.18812	19991.2493	0.21367	0.08959614	7.98055	0.47604	22.4443	0.07001	70.6285
3.18732	20023.2617	0.21394	0.08967215	7.98072	0.47739	22.4497	0.07002	70.6033
3.18723	20025.2190	0.21397	0.08968478	7.98088	0.47755	22.4552	0.07003	70.6001
3.18721	20025.7264	0.21397	0.08968579	7.98104	0.47756	22.4606	0.07003	70.5997
3.18721	20025.7450	0.21397	0.08968598	7.98121	0.47757	22.4660	0.07004	70.5996
3.18721	20025.7541	0.21397	0.08968599	7.98137	0.47757	22.4715	0.07004	70.5996
3.18721	20025.7547	0.21397	0.08968600	7.98154	0.47757	22.4769	0.07005	70.5996
				IROKO				
2.86339	18507	0.25	0.1	6.4	0.3	22.426	0.07	70
2.55362	14714.6272	0.21032	0.08938767	6.40008	0.39672	22.4321	0.07000	70.7512
2.52834	15916.8588	0.22131	0.09182965	6.40016	0.43814	22.4376	0.07001	70.6091
2.52620	15980.2464	0.22243	0.09228624	6.40023	0.44306	22.4426	0.07001	70.5018
2.52602	15991.0386	0.22253	0.09231518	6.40030	0.44352	22.4476	0.07002	70.4896
2.52600	15991.3786	0.22254	0.09231887	6.40037	0.44356	22.4525	0.07002	70.4885
2.52600	15991.4820	0.22254	0.09231907	6.40044	0.44356	22.4575	0.07003	70.4884
2.52600	15991.4826	0.22254	0.09231911	6.40051	0.44356	22.4625	0.07003	70.4884
2.52600	15991.4842	0.22254	0.09231911	6.40058	0.44356	22.4674	0.07004	70.4884
2.526	15991.4846	0.22254	0.09231911	6.40065	0.44356	22.4724	0.07004	70.4884

β	f_{bo}	w_t	t_t	ρ_t	S	ρ_s	t_s	P
				ABURA				
2.110136	14478	0.25	0.1	6	0.3	22.426	0.07	70
1.93072	11638.6104	0.22363	0.09303018	6.00005	0.37884	22.4310	0.07000	70.5069
1.92325	12499.2393	0.22942	0.09433318	6.00009	0.40383	22.4356	0.07001	70.3871
1.92270	12507.0797	0.23004	0.09456108	6.00013	0.40566	22.4399	0.070015	70.3268
1.92267	12511.9668	0.23006	0.09456719	6.00017	0.40580	22.4442	0.07001	70.3224
1.92267	12511.7904	0.23006	0.09456829	6.00022	0.40580	22.4484	0.07002	70.3220
1.92267	12511.8316	0.23006	0.09456829	6.00026	0.40580	22.4527	0.07002	70.3220
1.92267	12511.8288	0.23006	0.09456830	6.00030	0.40580	22.4570	0.07003	70.3220
1.92266	12511.8297	0.23006	0.09456830	6.00034	0.40580	22.4613	0.07003	70.3220
1.92266	12511.8300	0.23006	0.09456830	6.00039	0.40580	22.4655	0.07004	70.3220

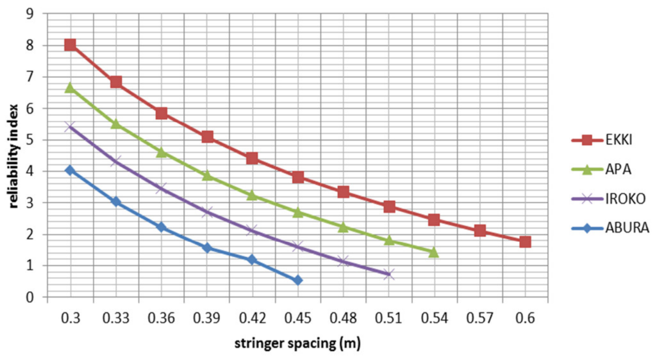

Figure 3 –Structural Safety Index: – Stringer spacing under varying loads.

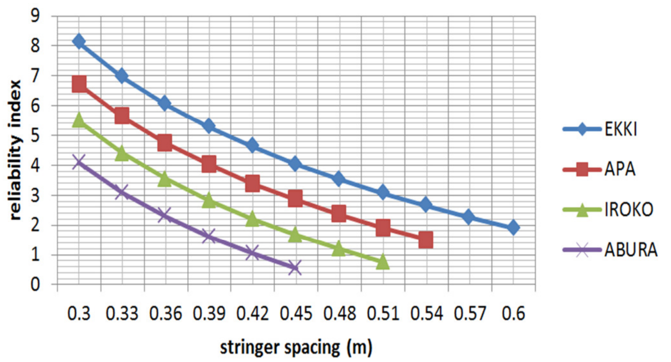

Figure 4–Structural Safety Index: Stringer spacing under constant loads

It can be observed from Table3 that the major factors which influence the performance function of planks for bridge decks are the grade stress, plank thickness and stringer spacing among other factors. Thus, the effect of these factors on structural safety is examined in the following sections.

4.1.1 Structural reliability assessment of Nigerian timbers in relation to stringer spacing under constant and varying loads

Figures 3 and 4 indicate clearly in a pictorial form, the implicit safety or reliability indices in relation to the stringer spacing for each wood class evaluated for use as bridge decks under constant and varying load respectively. It is observed that Nigerian timber species of strength classes N_1 and N_2, grade 80% (that is EKKI and APA) can comfortably be used for bridge decks with stringer spacing, S, ranging from 0.3 - 0.45m; with EKKI having a structural safety index as high as 8.019 (corresponding probability of failure, $p_f = 1 - \Phi(\beta) \approx 0$) at stringer spacing of 0.3m, and reliability index of 3.833 ($p_f \approx 6.33346E-05$) at stringer spacing of 0.45m, while for APA, the reliability index is 6.642 ($p_f \approx 1.54651E-11$) at stringer spacing of 0.3m, and reliability index of 2.703 ($p_f \approx 0.003436885$) at stringer spacing of 0.45m. For strength class N_3 (IROKO), the reliability index is 5.419 ($p_f \approx 3.175224E-08$) for timber deck supported on a stringer spaced at 0.3m, but at any thickness greater than 0.4m, the reliability index fall below the target probability of 0.25. Lastly, ABURA has a reliability index of 4.040 ($p_f \approx 2.67552E-05$) for timber at a stringer spacing of 0.3m but at any thickness greater than 0.34m, the reliability index falls below the target reliability.

4.1.2 Structural reliability assessment of Nigerian timbers in relation to plank thickness at 0.3m stringer spacing

Figure 5 indicates clearly in a pictorial form, the indicated safety or reliability indices in relation to plank thickness for each wood class evaluated for use as bridge decks at 0.3m stringer spacing.This figure shows that, the strength classes observed can all be used for bridge decking at stringer spacing of 0.3m. This is because the least of them which is ABURA in strength group N_4, has a reliability index of about 5.0 while others are higher this value.

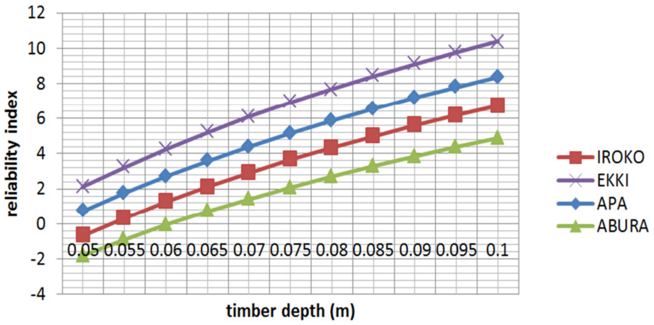

Figure 5 - Reliability index – Plank thickness at 0.3m stringer spacing.

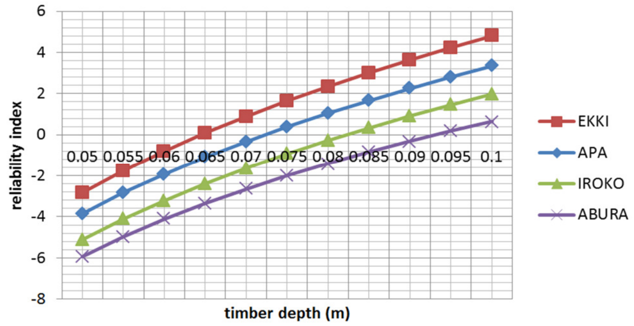

Figure 6 – Structural Safety Index: Plank thickness at 0.45m stringer spacing.

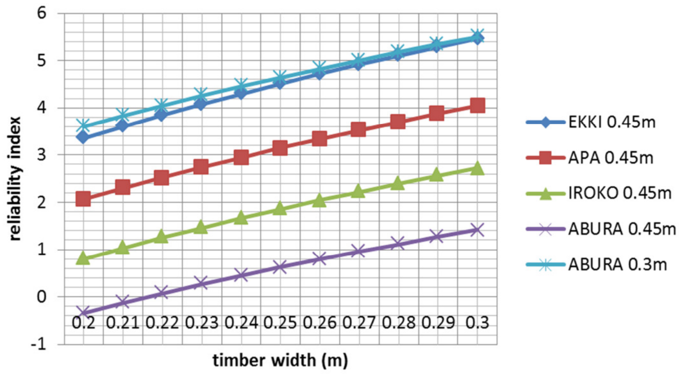

Figure 7 –Structural Safety Index: Plank width.

4.1.3 Structural reliability assessment of Nigerian timber species in relation to plank thickness at constant stringer spacing of 0.45m

Figure 6 indicates clearly in a pictorial form, the indicated safety or reliability indices in relation to plank thickness for each wood class evaluated for use as bridge decks at 0.45m stringer spacing. It was observed from the figure, that only Nigerian timber species in strength classes N_1 (EKKI) and N_2 (APA) can be used for bridge decking at a stringer spacing of 0.45m. The structural safety indices of IROKO and ABURA are about 2.0 and 1.0 respectively. These values are less than 2.5;but EKKI and APA have safety indices of about 5.0 and 3.5 respectively at this spacing.

4.1.4 Structural reliability assessment of Nigerian timbers in relation to plank width at constant stringer spacing

Figure 7 indicates clearly in a pictorial form, the structural safety or reliability indices in relation to planks width for each wood class evaluated for use as bridge decks at 0.3m and 0.45m stringer spacing. It is observed that, although the timber width may be reduced for ABURA at a stringer spacing of 0.3m to a minimum of 0.2m, the structure will not meet the target structural safety index or required safety at a stringer spacing of 0.45m; not even with a timber thickness of 0.1m and a width of 0.3m.

4.2 Damage accumulation reliability analysis results

Results for damage safety assessment for the effect of load accumulation over time with reference to bridge load for the four timber species assessed and which are proposed for bridge decks are given in Table 4. Table 4 shows the general stochastic reliability assessment of four Nigerian timber species representing various strength classes in progressive order; EKKI for strength class N_1, APA for class N_2, IROKO for class N_3 and ABURA for class N_4.

Table 4: Damage Accumulation Safety Assessment Of Proposed Species

t_f	$\sigma(t)$	f_0	β	p_f
		EKKI		
438000	95	23940	6.812120214	3.08433E-09
556617.3	118.0818	12877.62701	7.885119	2.89E-12
854777.4	128.7875	14500.72	7.885175	2.89E-12
964323.2	129.0599	14665.11	7.890448	2.78E-12
978154.3	129.0197	14676.49	7.89147	2.76E-12
		APA		
438000	95	23940	4.182466392	1.44182E-05
491442	109.4275	11825.95669	5.564637	1.31E-08
666261.9	114.9092	12698.86	5.561052	1.34E-08
706784.6	114.9654	12760.99	5.562589	1.33E-08
709507.5	114.9578	12763.81	5.562738	1.33E-08

t_f	$\sigma(t)$	f_0	β	p_f
		IROKO		
438000	95	18507	3.019065248	0.00126778
460607	104.8846	11281.94424	3.747934	8.91E-05
572768.8	107.359	11732.81	3.74454	9.04E-05
589840.6	107.3488	11757.04	3.745052	9.02E-05
590489.2	107.3469	11757.78	3.745078	9.02E-05
		ABURA		
438000	95	14478	1.625037246	0.052077311
437605.9	99.26417	10638.01509	1.893234	0.029163
486483.7	99.92608	10791.19	1.892287	0.029226
489753.4	99.92157	10795.94	1.892337	0.029223
489796.9	99.92146	10796	1.892337	0.029223

5. OBSERVATIONS

It is observed from the stochastic assessment, that the major factor influencing the performance function of timber bridge decks in accordance to AASTHO LRFD[12] are strength classes, timber thicknesses and stringer spacing among others. The structural safety indices were found to strongly depend on strength classes: with EKKI (class N_1) having the highest structural safety index of approximately 3.8491 at an appreciable possible point of failure with a timber depth of 0.087m, width of 0.205m and stringer spacing of 0.516m under an ultimate wheel load of 70.692kN.This is followed by APA (class N_2) with reliability index of 3.187, timber thickness of 0.090m, width of 0.214m, stringer spacing of 0.478m and ultimate wheel load of 70.599kN at the possible point of failure, then IROKO (N_3) with reliability index of 2.526, timber thickness 0.092m, width of 0.222m, stringer spacing of 0.444m and ultimate load of 70.488kN at the possible point of failure and lastly ABURA (N_4) with reliability index of 1.923, timber thickness of 0.095m, width of 0.230m stringer spacing of 0.406m under an ultimate load of 70.322kN at possible point of failure. Nowak and Saraf [11] states that stringers are spaced at, 0.3mto 0.6m center to center, but mostly 0.3m to 0.45m, while the planks are typically 0.1m x0.25m or 0.1m x0.3m. Thus, in relation to this, it will be observed that Nigerian timber species with strength class N_4 or lower will not be suitable for use as bridge decks, but there exist the possibility of using strength class N_4, grade 80% for bridge decks at stringer spacings lower than 0.4m with an appreciable increased timber thickness above 0.23m.

However, it is observed from Figure 5, that timber thickness for Nigerian timber species in strength class N_2 (APA) when used as bridge decks can be reduced to 0.06m with a structural safety or reliability index of 2.702 at 0.3m stringer spacing, and that of strength class N_3 (IROKO), can be reduced to 0.07m with reliability index of 2.904 at 0.3m stringer spacing, while that of strength class N_4 (ABURA), can be reduced to 0.08m at stringer spacing of 0.3m with reliability index of 2.707.

Lastly, Table 4 shows the reliability and approximate probability of failure over a predictable design period of 50 years. This probability of failure is based on the effect of load accumulation over time. Thus, it is clear that the possibility of failure over time still depends on the strength classes; with timber within the high strength classes having low probability of failure over time compared to timber with low strength classes: that is, strength class N_1 (for example, EKKI) with probability of failure, $p_f = 1 - \Phi(\beta) \approx 2.76\text{E} - 12$ over a period of 978154 hours (100 years), strength class N_3 (APA timber) with probability of failure, $p_f \approx 1.33\text{E} - 08$ over a period of 709508 hours (80 years), strength class N_3 (IROKO timber) with probability of failure, $p_f \approx 9.02\text{E} - 05$ over a period of 590489 hours (65 years) and strength class N_4 (ABURA timber) with probability of failure, $p_f \approx 0.029223$ over a period of 489797 hours (55 years).

6. CONCLUSION

This study assessed the possibility of using various Nigerian timber species as sustainable bridge deck materials and checks the long time viability of using them for bridge decks. Therefore, some suitable species were identified as possible source of sustainable and renewable planks for bridge decks. These include timbers within the range of strength classes $N_1$to N_4 out of the listed seven strength classes obtainable in the country. However, other classes may be used if they are upgraded to the requirement of strength classes N_1 to N_4 by available engineering treatments for timber.

The recommended strength classes with associated material properties can be a source of sustainable bridge deck materials over a reasonable period of time as indicated by the probability of failure as a result of damage due to load accumulation. Thus, this will enhance the use of Nigerian timber species and wood resources as innovative, sustainable and cost-effective materials for bridge decks, while promoting interest in the use of wood as a competitive bridge construction material by adding value to the use of local resources, and establishing a means of overcoming exclusion while also strengthening the inclusion of the use of timber in bridge construction industries.

7. RECOMMENDATION

The following recommendations should be considered in the construction of timber bridge decks using Nigerian timber species.

1. The most suitable strength classes for bridge decks are timbers with strength class $N_1$to $N_4$and any other timber with similar strength characteristics.
2. Timbers with a strength class lower than that of class N_4 should not be used for bridge decking, except when adequate engineering treatments have been performed on them in order to upgrade their strength classes to between N_1 and N_4 inclusive.
3. When using Nigerian timber for bridge decks, the stringers spacing should not be greater than 300mm with timber thickness of not less than 100mm, except for timber with strength class N_1, where the spacing can be increased to 450mm with a timber thickness not less than 100mm
4. The width of the planks for the timber decking should not be less than 250mm.

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