Mathematical Model for Flexural Strength of Laminated Sawdust-Palm kernel shellcrete Composite Slab

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The study presents the mechanical properties of plywood laminated sawdust-palm kernel shell composite slab. It provides panacea to the absence of flexural(bending) properties of sawdust-palm kernel shell composite core, which is a blend mix of cement, sawdust and palm kernel shell; and the flexural properties of plywood laminated sawdust-palm kernel shell composite slab. The materials used in the laboratory work included: Ordinary Portland Cement, sawdust, palm kernel shell, plywood, screw nails and water. Mechanical tests and physical properties tests were performed on the aggregates used in this study. Sawdust gave values of, 0.621, 35.46%, 601.5kg/m^3, 2.74, 2.91 and 1.01 for average specific gravity, water absorption, average bulk density, finess modulus, coefficient of uniformity (C_u) and coefficient of curvature (C_c) respectively. Palm kernel shell gave corresponding values of 731.14kg/m^3, 1.71, 12.1%, 7.14., 1.45 and 2.70 respectively. The materials were batched by volumetric method and converted to weight due to the lowunit weight of the aggregates (palm kernel shell and saw dust).The mixing of the fresh mix were done manually. A total of forty (40) slabs of size 1200 x 600 x 100mm(thickness), 1200 x 600 x 125mm(thickness), 1200 x 600 x 150mm, 1200 x 600 x 175mm(thickness) and 1200 x 600x 200mm(thickness) were cast for flexural(bending) strength of slab. Out of the forty (40) slabs cast; 20 were produced for the laminated sawdust-palm kernel shellcrete slab with slab thickness of 100mm, 125mm, 150mm, 175mm and 200mm, of which two(2) slabs were produced for each thickness using the mix ratios 0.9 : 1 : 2 : 2 and 0.9 : 1 : 2 : 3 respectively. The remaining 20 were produced for plain sawdust-palm kernel shellcrete slab with slab thickness of 125mm, 150mm, 175mm, 200mm and 225mm, of which two(2) slabs were produced for each thickness using the blend(mix) ratios 0.9 : 1 : 2 : 2 and 0.9 : 1 : 2 : 3 respectively. The average flexural(bending) strength of plywood laminated sawdust-palm kernel shell composite slab varies from 2.59MPa to 3.6MPa, while that of plain composite slab ranged from 1.52MPa to 3.21MPa. Comparing the plain composite slabs and plywood laminated slabs; the percentage difference in their flexural strength ranged from 9.25% to 75.21% and 0.7% to 77.1% for the mix ratios 0.9 : 1 : 2 : 2 and 0.9 : 1 : 2 : 3 respectively.

Index Terms — Sawdust, Palm kernel, Slab, Plywood, composite, slab thickness, Fexural strength

1 Introduction

Slab is one of the structural elements in structures usually found in buildings, bridges and drainages. It is mostly regarded as a less critical structural element in a structure when compared with its contemporaries (beams and columns) as a result of its possession of a large cross- sectional surface area [16]. Slab as an element can be constructed using different construction materials; some of which are costly, possess high self-weight, records high deflection, possess low flexure, pollutes the environment in the course of sourcing their constituent materials and other associated structural limitations. These different construction materials include: bamboo stick slab, timber slab, and composite members such as the conventional steel reinforced concrete (SRC), composite steel- concrete deck, wood – fibre board, bamboo- concrete reinforced, particle boards etc. The early form of slab is the bamboo stick slab usually used in mud houses in the 1940's; bamboo as a natural growing plant is known to have high tensile stress resistance than its contemporary materials [12]. It is highly low densed material, and a wide shock absorbing material. Thhe above properties justifies its use in the construction of light self-weight structure. Against the aforementioned pros of bamboo, it is only stronger at the nodal regions and points and it does not contain tranverse fibrous strands, thereby being weaker at the direction along the width [15]. It also have a low value of modulus of elastcity [17]. Bamboo contains gum, resin and starchy substances, thus requires appropriate pre-use treatment with appropriate chemicals prior to usage for construction purposes [13].

As a regular composite, Steel reinforced Concrete (SRC) slab is made by blending of cement, fine aggregate (Sand), coarse aggregate (granite), steel and water in a designed quantum. SRC is possess high compressive strength and resistive to acidic and microbial attacks. As a composite material, steel which possess high tensile and compressive strength, thus being called "reinforced concrete" made it a tenable and durable composite, moulded into differents patterns. This gave room for its versatile utility in civil works such as drainages, dams, culverts, buildings, drainages, bridges and road [18]. Contrary to the above, reinforced concrete slab possesses a high self weight which invariably increases the overall weight of the structure transmitted to the foundation thereby resulting to costly foundation structures [11]. In the same vein, due to high demand of reinforced concret; granite, cement, river sand and steel have become highly exorbitant and unaffordable to low earners [1]. Furthermore, the continuous increase in the use of conventional concrete materials such as coarse aggregates(granite) and river sand has led to an increase in both noise and environmental hazards (air and land pollution) in the course of their manufacturing processes [10]. Thus, the use of industrial and agricultural bye products (Sawdust and Palm kernel shell) becomes imperative as they are cheap, possess low self weight and poses no environmental hazards; such as saw dust and palm kernel shell. Against these backdrops and in bid to profer solutions to these aforementioned problems, this present study presents a composite slab produced by using a combination of plywood, sawdust, palm kernel shell and cement, and investigated its flexural strength.

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2 Materials and methods

2.1 Materials

The materials utilised in this study are: (i)Ordinary Portland cement (ii)Sawdust (iii)Palm kernel shell (iv)Water (v)12.5mm China Plywood (3 plies) (vi) 3inches screw nail

2.1.1 Ordinary Portland Cement

The ordinary Portland cement which conforms to the requirements of BS EN 197-1:2000 was obtained from Owerri, Imo State Nigeria.

2.1.2 Sawdust

Sawdusts were gotten from Owerri Timber Processing market, Imo State, Nigeria. Prior to usage, the sawdust boiled and rinsed to remove fats and acidic substances prior to usage. After boiling for about 3 hours of heating with water, the particles were rinsed and sun dried. The sawdust was classified according to the results of its physical properties as performed in the laboratory.

2.1.3 Palm kernel shell(PKS)

Palm kernel shell(PKS) was gotten from oil palm processing plant in Umukene community, Umuagwo village, Ohaji / Egbema LGA, Imo State, Nigeria. Prior to usage, PKS was boiled and rinsed to remove fats and oilic substances prior to usage. After boiling for about 3 hours of heating with water, the particles were rinsed and sun dried. The PKS was classified according to the results of its physical properties as performed in the laboratory.

2.1.4 Plywood

The plywood was purchased from timber Market. The grade of the plywood was C-C grade Exterior and Interior sheathing panel, that is, grade C group 1 veneers as was written on it with the sizing of 2400mm x 1200mm x 12.5mm (Three plies, 12.5mm thick). The plywood is made up of a roughly film faced exterior surface and a water-proof ply for water resistance and humid conditions In line with BS EN 635-1:1995, the plywood was physically inspected in order to ascertain there is no defect on it.

They were sawn to 600mm x 1200mm and used to produce laminated slabs to the following dimensions:

- 600mm x 1200mm x 125mm(thickness)
- 6000mm x 1200mm x 150mm(thickness)
- 600mm x 1200mm x 175mm(thickness)
- 600mm x 1200mm x 200mm(thickness)
- 600mm x 1200mm x 225mm(thickness)

2.1.5 Wood Glue/Adhesive

The adhesive used for the laminated composite slab is a synthetic glue purchased from the Owerri timber market known as “Top Bond White glue”. The synthetic adhesive comforms with the specification of ISO 848 -2006 and BS 4350 (1976). The choice of adhesive used was made based on its high shear strength, high viscosity, water resistant and compatible with fillers such as sawdust and sand.

2.1.6 Screw Nails as studs

The screwnails used for this research work were obtained from Owerri timber Market in Imo State, Nigeria and the size used was 3 inches’ steel nails conforming to BS1202-3: 1974.

2.2 Methods

The Test methods adopted on the plain sawdust- palm kernel shellcrete, laminated sawdust-palm kernel shellcrete slab were:

1. Test on characterisation of Plywood as a structural surfacing laminate.
2. Test for flexural strength characterisation of the Plywood laminated Sawdust-Palm kernel shellcrete composite slab.
3. Comparing the flexural strength of Plywood laminated Sawdust-Palm Kernel Shellcrete composite

slab with plain Sawdust-Palm Kernel Shellcrete composite slab.

4. Test to develop regression equation for determination of flexural strength of both laminated and plain sawdust-palm kernel shellcrete composite slab against the thickness.

The mixing method used for the production of Sawdust-Palm kernel shellcrete was manual method; The mix ratios for batching were 0.9 : 1 : 2 : 2 and 0.9 : 1 : 2 : 3 and the mix ratios stand for water cement ratio, cement, sawdust and palm kernel shell respectively.

2.2.1 Test on characterisation of Plywood as a structural surfacing laminate.

The split tensile and flexural strength of plywood at the direction perpendicular to the face and parallel to the face were obtained. The modulus of elasticity of the plywood in flexure was also obtained according to BS EN 12390-1 (2000) and BS EN 12390-5:2000, using (1) and (2) below. The result is as shown in Table1.

$$\text{Flexural Strength, } f_{cf} = \frac{F \times L}{b \times d_2{}^2} \quad (1)$$

$$Split\ tensile\ Strength, f_{st} = \frac{2F(N)}{\pi L d\ (mm^2} \quad (2)$$

2.2.2 Test for characterisation of the Plywood Laminated Saw dust- Palm kernel Shellcrete Slab

To determine the flexural strength of sawdust-palm kernel shellcrete laminated composite slabs, the following were conducted:

2.2.2.1 Production of Plywood Laminated Composite Slab

The 12.5mm (½ inch) thick plywood for the laminates were sawn into appropriate sizes. Also, the saw dust – palm kernel shellcrete slabs to be laminated produced were of the sizes: 1200mm x 600mm x 100mm(thickness), 1200mm x 600mm x 125mm(thickness), 1200mm x 600mm x 150mm(thickness), 1200mm x 600mm x 175mm(thickness) and 1200mm x 600mm x 200mm(thickness); having core thicknesses, h, as shown in Fig.1.

Holes of 8mm diameter for the studs insertion were also drilled on the plywood with pitch spacing of 275mm and 250mm for both the longer and shorter length using a common end distance of 50mm respectively. To make sure that there was proper bond and lamination between sawdust-palm kernel shellcrete and the plywood, a wood- cement adhesive was applied evenly on the top face and bottom face of the laminates at 1.5mm thickness. This is necessary to avoid delamination. Afterwards, the studs (screw nails) were inserted and stiffened for a proper shear resistance between the core(composite) and plywood. A total of 40 saw dust – palm kernel shellcrete slabs were produced with mix ratios of 0.9 : 1 : 2 : 2 and 0.9 : 1 : 2 : 3. Out of which 20 slabs were laminated with plywood while the other 20 slabs were non – laminated. The aforementioned water-cement ratio and mix ratio was adopted on the basis of the high water absorption rate of the constituent materials, unit weight, workability and to attain the desirable optimum strength and durability for light weight concrete.

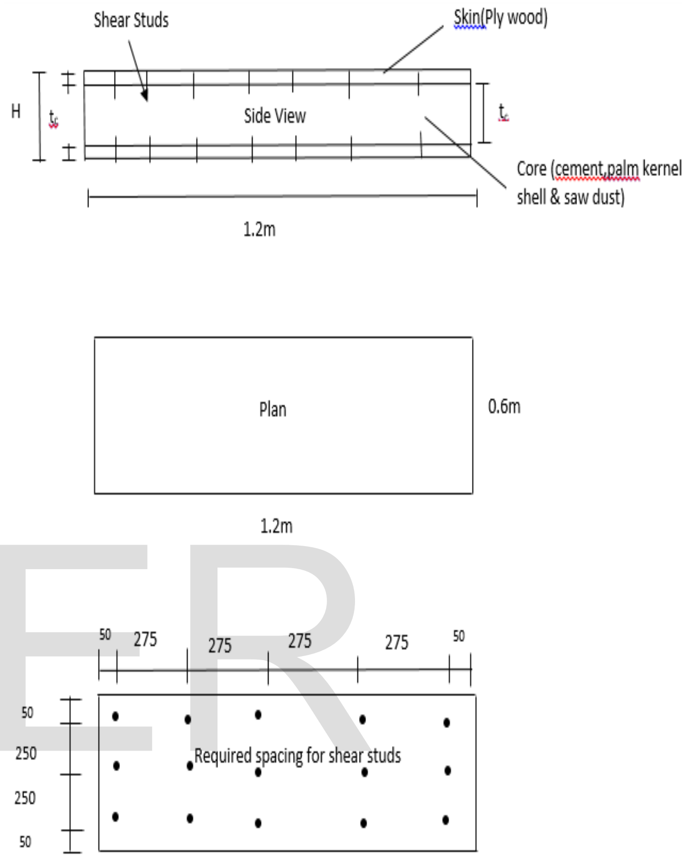

Fig. 1: Typical plywood laminated composite slab

The dimension of the non- laminated sawdust-palm kernel shellcrete slab (plain sawdust-palm kernel shell without plywood laminate) produced were 1200mm x 600mm x 125mm(thickness), 1200mm x 600mm x 150mm(thickness), 1200mm x 600mm x 175mm(thickness), 1200mm x 600mm x 200mm(thickness) and 1200mm x 600mm x 225mm(thickness); having combined thicknesses, H, of both the plywood and the core as shown in Fig. 1. The conventional concrete slabs were cast with mix ratio of 0.45:1:2:4. The size of the slabs produced were 1200mm x 600mm x 125mm, 1200mm x 600mm x 150mm, 1200mm x 600mm x 175mm, 1200mm x 600mm x 200mm and 1200mm x 600mm x 225mm; having combined thicknesses, H, of both the plywood and the sawdust-palm kernel shellcrete as shown in Fig. 1.

All slabs were produced using manual mixing method and proper vibration so as to obtain good compaction and were cured by water sprinkling for 28 days. Thereafter, it was tested with Magnus frame, with an installed Enerpac hydraulic pressure jack to determine its flexural strength. The compression load at failure were recorded and in (3) was used to determine the flexural strength for all the slab types.

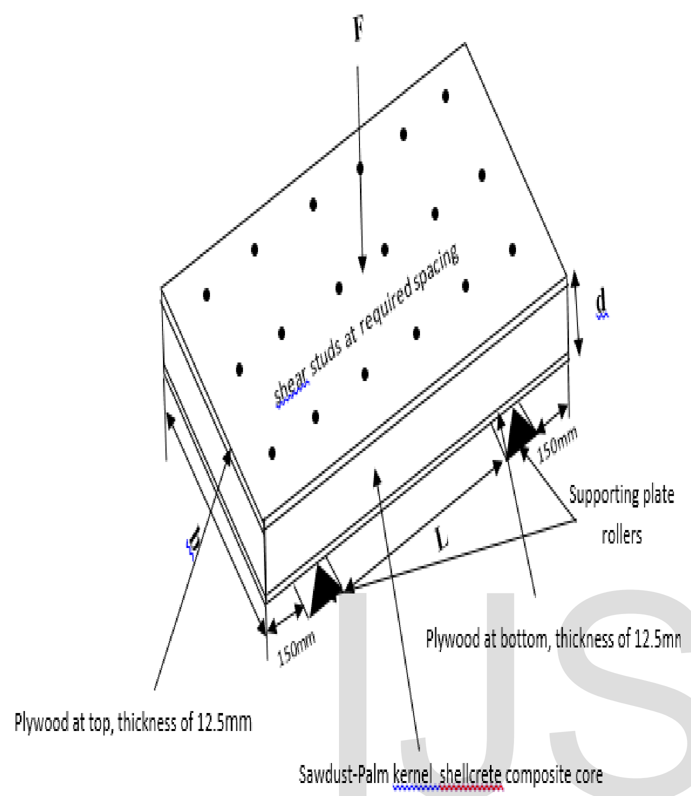

Fig.2: Arrangement of slab during crushing as required by BS EN 12390-5:2009.

2.2.2.3 Test for Flexural(bending) Strength Test of Plywood laminated Slab and unlaminated Slab

Flexural(bending) tests were done in order to obtain the flexural strength of the Sawdust-palm kernel shellcrete plywood laminated slab, unlaminated composite slab and conventional concrete slab. The tests were done according to BS EN 12390-5:2000 as shown on Fig.2. The result is as shown in Table 2 and Table 3 respectively.

$$\text{Flexural Strength, } f_{cf} = \frac{F \times L}{b \times d_2{}^2} \quad (3)$$

Where.

F is the failure load (N);

is the length from one end support roller to another (in mm)

b is the breadth and d is the depth of slab cross-section (in mm);

Failure load, F is obtained based on the specification of the Enerpac hydraulic pressure jack installed on the Magnus frame shown in Fig.2.

The failure load, F can be obtained using (4):

$$\text{Failure load, F} = \frac{\text{Pressure exerted on the hydraulic cylinder(Psi or N/mm}^2)}{\text{Effective area of Hydraulic cyliinder(mm}^2)} \quad (4)$$

For slab b = 600mm, d = depth of slab ranging from 100mm – 225mm

L is the length from one end support roller to another (in mm); for slab L= 900mm.

2.2.2.4 Comparing Flexural Strength of Plywood laminated Sawdust–Palm Kernel Shellcrete slab with unlaminated Sawdust–Palm Kernel Shellcrete composite Slab

To determine the closeness of flexural strength of laminated Sawdust-Palm Kernel Shellcrete slab and Plain slabs, the percentage difference between flexural strength of the laminated composite slab and that of the plain composite slab were computed. This was to ascertain the percentage differences between the flexural strength of plywood laminated composite slabs and plain composite slabs. The result is as shown in Table 5 and Table 6 respectively.

2.2.2.5 Development of regression/mathematical equation for determination of flexural strength of plywood laminated sawdust-palm kernel shellcrete composite slabs and that of unlamianted slab against the thickness.

To obtain the correlation between the flexural(bending) strength of slabs and their thicknesses, correlation models/ regression equations were developed for the purpose of knowing the relationship existing between the flexural strength of plywood laminated slab and its thicknesses, flexural strength of plain composite slab and its thicknesses. This is to ascertain the variation in the relationship between the flexural strength and slab thicknesses of the two(2) slab types with the different mix ratios.

Regression models were developed for the plywood laminated composite slab by plotting a linear graph of their flexural strength against their various slab thicknesses for the mix ratio of 0.9:1:2:2 and 0.9:1:2:3 respectively. In the same vein, regression models were also developed for the plain composite slab by plotting a linear graph of their flexural strength against their various slab thicknesses for the mix ratio of 0.9:1:2:2 and 0.9:1:2:3 respectively. The result is as shown in Figure 3 to Figure 6 respectively.

2 RESULTS AND DISCUSSION

2.1 RESULTS

The results obtained for this research work were presented on Table 1 to Table 10 and Figure 3 to Figure 6.

3.1.1 Results on characterization of plywood as a structural surface laminate

The results of the strength test results for plywood were as presented in Table 1:

3.1.2 Results on characterization of plywood laminated Sawdust-Palm Kernel shellcrete composite slab

The results of the flexural strength of plywood laminated sawdust-palm kernel shellcrete slab and those of unlaminated sawdust-palm kernel shellcrete slab are as displayed on table 2 to Table 6

TABLE 6
RESULTS ON STRENGTH TEST VALUES OF PLYWOOD

Size and Number of ply Respectively	Bending(Flexure): perpendicular to Span N/mm^2	Tension Parallel to face N/mm^2	Tension Perpendicular to face grain N/mm^2	Compressive Strength N/mm^2	Modulus of Elasticity in Bending N/mm^2
12.5mm (3plies)	4.35	3.93	3.93	19.43	8.13
12.5mm (3plies)	4.37	3.95	3.94	19.5	8.1
12.5mm (3plies)	4.39	3.99	3.96	19.56	8.09
AVERAGE	4.37	3.95	3.94	19.51	8.11

TABLE 2

RESULTS ON 28TH DAY FLEXURAL STRENGTH VALUES OF PLYWOOD LAMINATED SAWDUST-PALM KERNEL SHELLCRETE SLAB

Mix ratio (cement:sawdust:PKS)	Thickness of plywood (mm)	Slab size (mm)	Sample No	Crushing load (KN)	Flexural (bending) strength (N/mm²)	Mean Flexural (bending) strength (N/mm²)
1:2:2	12.5	1200 x 600 x 100	A	19.51	2.93	2.81
1:2:2			B	17.98	2.70	
1:2:2	12.5	1200 x 600 x 125	A	31.56	3.03	3.15
1:2:2			B	33.98	3.26	
1:2:2	12.5	1200 x 600 x 150	A	49.11	3.27	3.37
1:2:2			B	51.99	3.47	
1:2:2	12.5	1200 x 600 x175	A	68.55	3.36	3.46
1:2:2			B	72.77	3.56	
1:2:2	12.5	1200 x 600 x 200	A	92.89	3.48	3.52
1:2:2			B	94.77	3.55	
1:2:3	12.5	1200 x 600 x 100	A	17.97	2.70	2.62
1:2:3			B	16.99	2.55	
1:2:3	12.5	1200 x 600 x 125	A	30.99	2.98	3.02
1:2:3			B	31.97	3.07	
1:2:3	12.5	1200 x 600 x 150	A	48.77	3.25	3.19
1:2:3			B	46.99	3.13	
1:2:3	12.5	1200 x 600 x175	A	65.89	3.23	3.20
1:2:3			B	64.88	3.18	
1:2:3	12.5	1200 x 600 x 200	A	89.32	3.35	3.28
1:2:3			B	85.67	3.21	

Note*: A & B are the replicates of the slabs used for the test.*

TABLE 3

RESULTS ON 28TH DAY FLEXURAL STRENGTH VALUES OF PLAIN SAWDUST-PALM KERNEL SHELLCRETE COMPOSITE SLAB

MIX RATIO (CEMENT:SAWDUST:PKS)	SLAB SIZE (MM)	SAMPLE NO	CRUSHING LOAD (KN)	FLEXURAL STRENGTH (N/MM²)	MEAN FLEXURAL STRENGTH (N/MM²)
1:2:2	1200 x 600 x 125	A	17.51	1.68	1.61
1:2:2		B	15.98	1.53	
1:2:2	1200 x 600 x 150	A	37.66	2.51	2.49
1:2:2		B	36.98	2.47	
1:2:2	1200 x 600 x 175	A	59.11	2.90	2.87
1:2:2		B	57.99	2.84	
1:2:2	1200 x 600 x200	A	81.93	3.07	3.11
1:2:2		B	83.70	3.14	
1:2:2	1200 x 600 x 225	A	106.89	3.17	3.21
1:2:2		B	109.77	3.25	
1:2:3	1200 x 600 x 125	A	16.78	1.61	1.52
1:2:3		B	14.99	1.44	
1:2:3	1200 x 600 x 150	A	35.99	2.40	2.40
1:2:3		B	35.97	2.40	
1:2:3	1200 x 600 x 175	A	56.77	2.78	2.76
1:2:3		B	55.99	2.74	
1:2:3	1200 x 600 x200	A	79.89	3.00	3.05
1:2:3		B	82.88	3.11	
1:2:3	1200 x 600 x 225	A	103.32	3.06	3.13
1:2:3		B	107.67	3.19	

***Note**: A & B are the replicates of the slabs used for the test.*

TABLE 4

RESULTS ON DEFLECTION VALUES OF PLYWOOD LAMINATED SAWDUST-PALM KERNEL SHELL COMPOSITE SLAB

MIX RATIO (CEMENT:SAWDUST:PKS)	THICKNESS OF PLYWOOD (MM)	SLAB SIZE (MM)	SAMPLE NO	FLEXURAL STRENGTH (N/MM²)	DEFLECTION (MM)
1:2:2	12.5	1200 x 600 x 100	A	2.81	93.50
1:2:2			B		
1:2:2	12.5	1200 x 600 x 125	A	3.15	79.60
1:2:2			B		
1:2:2	12.5	1200 x 600 x 150	A	3.37	55.50
1:2:2			B		
1:2:2	12.5	1200 x 600 x175	A	3.46	38.90
1:2:2			B		
1:2:2	12.5	1200 x 600 x 200	A	3.52	28.50
1:2:2			B		
1:2:3	12.5	1200 x 600 x 100	A	2.62	107.80
1:2:3			B		
1:2:3	12.5	1200 x 600 x 125	A	3.02	83.50
1:2:3			B		
1:2:3	12.5	1200 x 600 x 150	A	3.19	60.90
1:2:3			B		
1:2:3	12.5	1200 x 600 x175	A	3.20	39.90
1:2:3			B		
1:2:3	12.5	1200 x 600 x 200	A	3.28	29.60
1:2:3			B		

***Note**: A & B are the replicates of the slabs used for the test.*

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3.1.3 Results of comparison between the flexural strength of plywood laminated sawdust- palm kernel shellcrete slab and those of plain composite slab

The results of the flexural strength comparison between plywood laminated sawdust-palm kernel shellcrete slab and plain composite slab are presented below in Table 4.13 to Table 4.14.

TABLE 5

PERCENTAGE DIFFERENCE OF THE VALUES OF FLEXURAL STRENGTH OF PLYWOOD LAMINATED SLAB AND PLAIN SAWDUST - PALM KERNEL SHELLCRETE SLAB AT 0.9:1:2:2 MIX RATIO

slab thickness(mm)	Z_1	Z_3	Z_1-Z_3	Percentage diff. (%) $=\frac{Z_1-Z_3}{Z_1}\times 100$	Average Percentage diff. (%)
100	2.93	1.68	1.25	42.56	42.84
100	2.70	1.53	1.16	43.12	
125	3.03	2.51	0.52	17.13	20.78
125	3.26	2.47	0.80	24.42	
150	3.27	2.90	0.38	11.57	14.81
150	3.47	2.84	0.63	18.05	
175	3.36	3.07	0.29	8.49	10.22
175	3.56	3.14	0.43	11.94	
200	3.48	3.17	0.32	9.08	8.78
200	3.55	3.25	0.30	8.48	

Z1 = Flexural strength Plywood laminated sawdust-palm kernel shellcrete in MPa, made from 0.9:1:2:2
Z3 = Flexural(bending) strength of Plain sawdust-palm kernel shellcrete in MPa, made from 0.9:1:2:2

TABLE 6
PERCENTAGE DIFFERENCE OF THE VALUES OF FLEXURAL STRENGTH OF PLYWOOD LAMINATED SLAB AND PLAIN SAWDUST - PALM KERNEL SHELLCRETE SLAB AT 0.9:1:2:3 MIX RATIO

SLAB THICKNESS(MM)	Z_1	Z_3	Z_1-Z_3	PERCENTAGE DIFF. (%) $=\frac{Z_1-Z_3}{Z_1}\times 100$	AVERAGE PERCENTAGE DIFF. (%)
100	2.70	1.61	1.08	40.24	41.89
100	2.55	1.44	1.11	43.53	
125	2.98	2.40	0.58	19.35	20.61
125	3.07	2.40	0.67	21.87	
150	3.25	2.78	0.47	14.48	13.47
150	3.13	2.74	0.39	12.46	
175	3.23	3.00	0.23	7.17	4.69
175	3.18	3.11	0.07	2.20	
200	3.35	3.06	0.29	8.60	4.65
200	3.21	3.19	0.02	0.70	

Z1 = Flexural strength Plywood laminated sawdust-palm kernel shellcrete in MPa, made from 0.9:1:2:3
Z3 = Flexural(bending) strength of Plain sawdust-palm kernel shellcrete in MPa, made from 0.9:1:2:3

3.1.4 Development of regression equation for determination of flexural strength sawdust-palm kernel shellcrete plywood laminated core slab

The regression equations for determination of flexural strength of plywood laminated core slab at different mix ratios considered in this research were developed by plotting the graph of flexural strength at different thickness of the slab for different mix ratios. The graphs are presented in Fig 3 - Fig6 and Table 7 to Table 10:

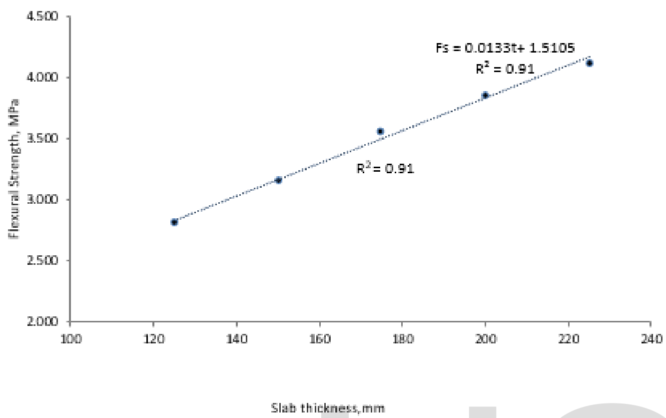

FIG 3 REGRESSION GRAPH OF FLEXURAL STRENGTH OF PLYWOOD LAMINATED CORE SLAB AGAINST SLAB THICKNESS USING 1:2:2 MIX RATIO

TABLE 7
REGRESSION MODEL OF FLEXURAL STRENGTH OF PLYWOOD LAMINATED CORE SLAB AGAINST SLAB THICKNESS USING 1:2:2 MIX RATION

Variable	Coefficient	Intercept	R^2	Correlation Equation/Model
Flexural Strength,Fs	1	1.510	0.91	Fs = 0.0133t +1.510
Slab thickness, t	0.0133			

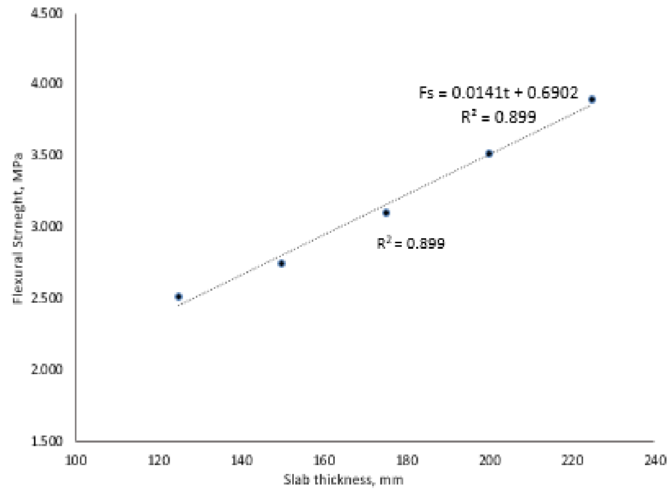

FIG 4 REGRESSION GRAPH OF FLEXURAL STRENGTH OF PLYWOOD LAMINATED CORE SLAB AGAINST SLAB THICKNESS USING 1:2:3 MIX RATIO

TABLE 8
REGRESSION EQUATION / MODEL OF FLEXURAL STRENGTH OF PLYWOOD LAMINATED CORE SLAB AGAINST SLAB THICKNESS USING 1:2:3 MIX RATIO

Variable	Coefficient	Intercept	R^2	Correlation Equation/Model
Flexural Strength,Fs	1	0.6902	0.89	Fs = 0.014t +0.6902
Slab thickness, t	0.014			

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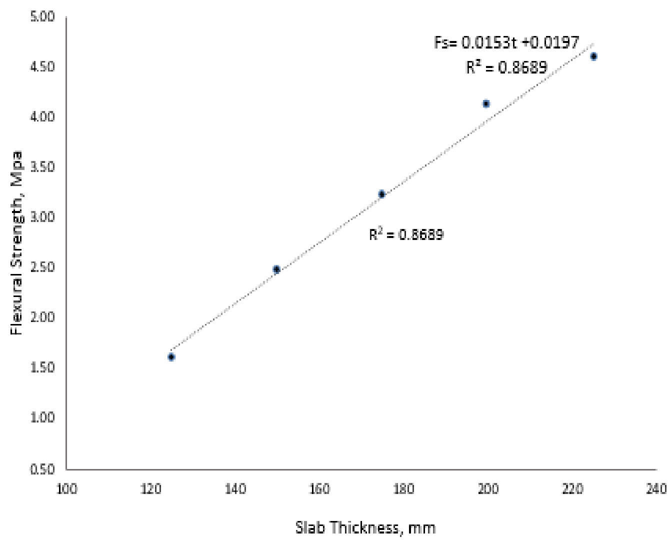

FIG 5: REGRESSION GRAPH OF FLEXURAL STRENGTH OF PLAIN SAWDUST PALM KERNEL SHELLCRETE SLAB AGAINST SLAB THICKNESS USING 1:2:2 MIX RATIO

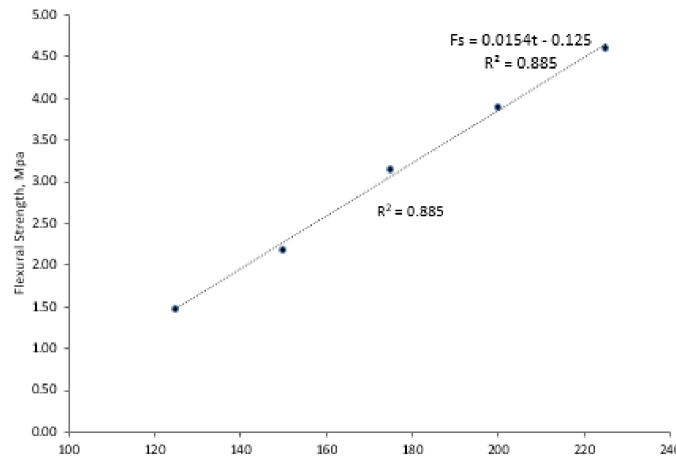

FIG 6: REGRESSION GRAPH OF FLEXURAL STRENGTH OF PLAIN SAWDUST PALM KERNEL SHELLCRETE SLAB AGAINST SLAB THICKNESS USING 1:2:3 MIX RATIO

TABLE 9

REGRESSION EQUATION / MODEL OF FLEXURAL STRENGTH OF PLAIN SAWDUST PALM KERNEL SHELLCRETE SLAB AGAINST SLAB THICKNESS USING 1:2:2 MIX RATIO

Variable	Coefficient	Intercept	R^2	Correlation Equation/Model
Flexural Strength,Fs	1	0.0197	0.87	Fs = 0.0153t +0.0197
Slab thickness, t	0.0153			

TABEL 10

REGRESSION EQUATION / MODEL OF FLEXURAL STRENGTH OF PLAIN SAWDUST PALM KERNEL SHELLCRETE SLAB AGAINST SLAB THICKNESS USING 1:2:3 MIX RATIO

Variable	Coefficient	Intercept	R^2	Correlation Equation/Model
Flexural Strength,Fs	1	-0.125	0.88	Fs = 0.0154t -0.125
Slab thickness, t	0.0154			

3.2 Discussion

The plywood had an average flexural strength 4.37N/mm2 for the face perpendicular to span and average compressive strength of 19.51N/mm2; the average static modulus of elasticity was found at 8.11N/mm2, the values comforms relatively with those from literature. According to BS EN 636(2005), this classifies the 12.5mm china plywood under F-8 stress grade.

The average flexural strength of plywood laminated sawdust-palm kernel shellcrete composite slab ranges from 2.62MPa to3.52MPa while that of sawdust-palm kernel shell beams has a range of 2.49MPa to 2.8MPa. The flexural strength of normal concrete slab gave 3.97MPa to 6.02MPa but the allowable bending stress for concrete ranges from 2.6MPa to 17MPa. This conforms within the limit of light weight concrete slab.

The result in Table 5 shows that the percentage difference between the flexural strength of plywood laminated sawdust-palm kernel shellcrete slabs and plain sawdust-PKS slabs made from mix ratios 0.9:1:2:2, increases with increase in slab thickness and ranges from 8.78% to 42.84%. Also, the result in Table 6, the percentage difference between the flexural strength of plywood laminate sawdust- palm kernel shellcrete slabs and plain sawdust-PKS slabs made from mix ratios 0.9:1:2:3, increases with increase in slab thickness and ranges from 4.65% to 49.89%. The graphs of flexural strength plotted against thickness of slab in Fig 3 –Fig 6 show that the relationship between the flexural strength and slab thickness are as summarized in Table 11.

The graphs obtained in Figure 4.1 – 4.4 were linear graphs

TABLE 11

REGRESSION EQUATION / MODEL OF FLEXURAL STRENGTH OF PLAIN SAWDUST PALM KERNEL SHELLCRETE SLAB AGAINST SLAB THICKNESS USING 1:2:3 MIX RATIO

Mix ratio	Type of slab	Regression equation	R^2
0.9:1:2:2	Laminated sawdust - PKS slab	$F_s = 0.0133t + 1.510$	0.91
0.9:1:2:3	Laminated sawdust - PKS slab	$F_s = 0.014t + 0.6902$	0.899
0.9:1:2:2	Plain sawdust - PKS slab	$F_s = 0.0153t + 0.0197$	0.87
0.9:1:2:3	Plain sawdust - PKS slab	$F_s = 0.0154t - 0.125$	0.88

with high value of R^2 (i.e $R^2 > 0.85$). This shows that there is exact relationship between the flexural strength of the slab and its thicknesses.

4 CONCLUSION

In the quest to achieve the specific objectives, the sawdust-palm kernel shellcrete were structurally characterized in relation to its Flexural strength.

The mean flexural or bending strength of sawdust-palm kernel shell beams ranged from 2.48MPa to 2.81MPa. For slabs; the average flexural strength of plywood laminated sawdust-palm kernel shell composite slab has a range of 2.61MPa to 3.54MPa, that of plain core slab ranged from 1.52MPa to 3.21MPa, while that normal concrete slab gave 3.98MPa to 6.03MPa but but the allowable bending stress for concrete ranges from 2.6MPa to 17MPa according to BS EN 12390-5:2000. Therefore the flexural strength falls within the limit of light weight concrete slab.

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