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Flexural & Compressive Characteristics of partially replaced Sawdust-Crack filler Palm kernel shell blendSlab using wood adhesive

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ABSTRACT :*Theresearchworkentails the Structural propertiesof High bendingStrength - LightweightcompositeSlab. It gives light to the solutions to limitations, literature and experimental data with respect to the structural properties of High bendingStrength - Light Weightcomposite slab, whichis a composite blend of woodadhesive, crack-filler, sawdust, palm kernelshell and plywood. The elementalmaterialsused in thisresearchworkincluded: woodadhesive, crack-filler, sawdust, palm kernelshell and plywood. The physicalcharacterisation tests wereimplemented on elementalmaterialsabove; sawdust gave values of 2.72, 561.6kg/m3, 1.02, 0.61, 40.26% and 2.95 for finessmodulus, averagebulkdensity, coefficient of curvature (Cc), averagespecificgravity, average water absorption and uniformity (Cu) respectively. Palm kernelshell gave corresponding values of 7.45, 1.51, 811.75kg/m3, 1.83, 12.4% and 2.74.A total of ten (10) cubes of size 150 x 150 x 150mm, ten (10) cylinders of size 150 x 300mm and ten (10) beams of size 150 x 150 x 600mm wereproducedfrom mix ratios: 0.5 : 0.5 : 1.5: 0.5 & 0.5 : 0.75 : 1.5: 0.5 (WA: CF : SD : PKS) for compressionstrength test, split tension strength test and bendingstrength test. The above water-cement ratio and blend ratios wereselected by virtue of the water absorption affinity of the elementalmaterials, desiredworkability, strength and durabilityfor high blend-lightweightcomposite slab. A total of twenty (20) slabs of size 350mm square slabwiththickness of 125mm, 150mm, 175mm, 200mm, and 225mm werecast for flexuralstrength of slab.*

For the slabs, themeancompressivestrength, mean dry density, mean split tensile strength and mean static modulus of elasticity, mean poisson ratio, mean shear modulus, mean shear strength, mean flexural strength and mean deflection ranged from 14.91MPa to 15.78MPa, 1446.914 Kg/m³ to 1534.815 Kg/m³ 2.37MPa to 2.51MPa, 8.68MPa to 9.95MPa, 0.16, 3.74GPato 4.29GPa, 2.77MPa to 2.52MPa, 5.06MPa to5.52MPa & 5.08MPa to5.55MPa and 28.9mm to 86.5mm & 29.85mm to 50.7mm for both mix ratio 0.5: 0.5: 2 and 0.5: 0.75: 2 respectively.

KEYWORDS-*Wood Adhesive, Crack Filler, Saw dust, Palm kernel shell, Flexural strength, Deflection, compressive strength*

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I. INTRODUCTION

Slab otherwise known as plate is an elemental part of a structure usually found in buildings, walk ways and other civil structures. Slab not being part of a structural frame is usaully referred to be a low sensitive element in a structure when compared with others like beams and columns. This is due to the fact that it has a largersurface area [4]. Slab as a structural element can be cast using various structural materials; some of which are exhorbitant in price, has high dead weight, high rate of yielding, has low bending strength, degrades the environment in the course of minning of theraw materials and other related limitations. These various building materials include: plywood, fibres bamboo stick slab, timber slab, and composite members such as the concrete-steel reinforced slab, steel stud-concrete deck, particle-fibre board etc. The ancientform of slab is the bamboo stick slab usually used in mud-clay houses in the 1920's; bamboo as a fibrous plant is regarded to be tensile stress resistant than its contemporaries [2]. It has low unit weight as a physical property, and a high shock

absorbant. The above properties justifies its use in the construction of light self-weight structure. Contrary to the good sides of bamboo, it possesses stiffness only at the nodal zone and does not contain transversal strands, thereby being less stiffer at the direction parallel to the nodes [5]. It also have a low value of modulus of elastcity [7]. Bamboo constitutes of gum, resin and starchy substances, thus requires proper treatment using proper chemicals before construction utility purposes [10].

As a routine composite element, concrete-Steel reinforced slab is madeby constitution ofcement,fineaggregate(Sand), coarseaggregateusually granite, steel and water in adesignedproportion. Concrete-Steel reinforced (CSR)possess high compression stress resistanceandresistance toacidicandmicrobial attacks. As a composite element,steelhas high tensile strength and high compression strength, thusbeing referred to as"Reinforcedconcrete" made it atenaciousanddurable composite, cast into various patterns. This gave rise for the wide utility incivil workssuchaswalk ways, cover slabs, Tank stands, culverts, drainages, bridges and pavements[8]. Contrary to the above, reinforced concrete slab(RC) possesses a high dead weightwhich directly increases the gross weight of the structure transferred to the foundation thus give rise to expensive foundation structures [3]. In similar view,due to rise in demand of reinforced concret slab; its component materials such as granite, cement, riversand and steel have become highly expensiveand unaffordable to average citizens[1].Moreso, the insessant increase in the usage of routine concrete materials which includes coarse aggregates(granite) and river sand has led to ecological hazards (air, water and land pollution) in the course of their minning processes [9]. Thus, the utility of industrial and agricultural waste products (Sawdust and Palm kernel shell) becomes valuable as they are cheap, possess low self-weight and poses no ecological harm; such as saw dust and palm kernel shell. Against these cons and in bid to profer solutions to these aforementioned backdrops and limitations, this study presents a composite slab produced by using a composition of wood adhesive, crackfiller, plywood, sawdust and palm kernel shell.

II. MATERIALS AND METHOD

The component materials utilised in this study are: (i)Crack filler(ii)Sawdust (iii)Palm kernel shell (iv)Water (v)12.5mm China Plywood (vi) wood glue

Crack filler

Crack filler was purchased from the saw mill market, Owerri west LGA, Imo State, Nigeria. The crack filler was grouped according to the results of its physiochemical properties as carried out in the laboratory. The chemical composition of the crack filler include: Talc (magnesium hydroxide), kaolin, carbon, calcium carbonate and calcium oxide(quicklime).

Sawdust

Sawdusts were freely gotten from saw mill market Imo State, Nigeria. Prior to usage, the sawdust wasboiled and rinsed to rid off wax and organic matter prior to usage. The sawdust was classified and grouped according to the results of its physical properties as carried out in the laboratory.

Palm kernel shell(PKS)

Palm kernel shell(PKS) was gotten from palm processing mill in Umukene community, Umuagwo village, Ohaji / Egbema LGA, Imo State, Nigeria. Before usage, PKS was boiled and rinsed to remove organic and inorganic matters prior to usage. The PKS was classified according to the results of its physical properties as carried out in the laboratory.

Plywood

The plywood was procured from wood mill Market in Owerri, Imo State. The grade of the plywood was C grade Exterior and Interior veneer, with the sizing of 350mm x 350mm x 12.5mm (Three plies, 12.5mm thickness). The plywood is made up of a rough exterior surface in line with BS EN 855-1:1998, the plywood was physically inspected in order to ascertain there is no crack, knots and other defection on it.
They were sawn to 350mm x 350mm and used to pro-duce laminated slabs to the following dimensions:

- 350mm x 350mm x 125mm
- 350mm x 350mm x 150mm
- 350mm x 350mm x 175mm
- 350mm x 350mm x 200mm
- 350mm x 350mm x 225mm

Wood Glue

The wood glue utilised for the laminated composite slab is a synthetic wood glue purchased from the wood mill in Owerri, Imo State. The synthetic glue comforms with the standard of ISO 656 -2010and BS 5560 (1996).

The selection of the wood glue was based on its shear strength, high viscosity, high resistant to moisture and compatible with fillers such as sawdust and sand.

Production of Plywood Laminated Composite Slab

The one and half (½ inch) thick plywood for the laminates were cut into required sizes. Also, the composite lightweight slabs to be laminate were of the sizes: 350mm x 350mm x 100mm(thick), 350mm x 350mm x 125mm(thickness), 350mm x 350mm x 150mm(thick), 350mm x 350mm x 175mm(thick) and 350mm x 350mm x 200mm(thick); having core thicknesses, h, as shown in Fig.1.

To ensure tenacious bonding and lamination between composite slab and the plywood, a wood adhesive/glue was applied evenly on the top face and bottom face of the laminates at 2mm thickness. This is necessary to avoid debonding of the two different materials. A total of 20 composite slabs were produced with mix ratios of0.5: 0.5 : 1.5: 0.5 and 0.5 : 0.75 : 1.5: 0.5. A total number of 10 slabs for mix ratio 0.5: 0.5 : 1.5: 0.5 and total number of 10 slabs for 0.5: 0.75 : 1.5: 0.5 respectively. About 20 slabs were produced and laminated with plywood. The prementioned water/cement ratio and blend ratio was obtained based on the high water absorption rateof the individual materials, unit weight, workability nature and the need to reach the optimum strength of light-weight concrete.Manual mixing method was adopted for all slabs and so as to attain good compactive level. Lastly, the slabs were subjected to compression test using a Magnus frame, with an attachedEnerpac hydraulic pressure jack to detect its flexural strength.
The compression load at yield point were recorded and was utilised to derive the flexural strength for all the slab types.

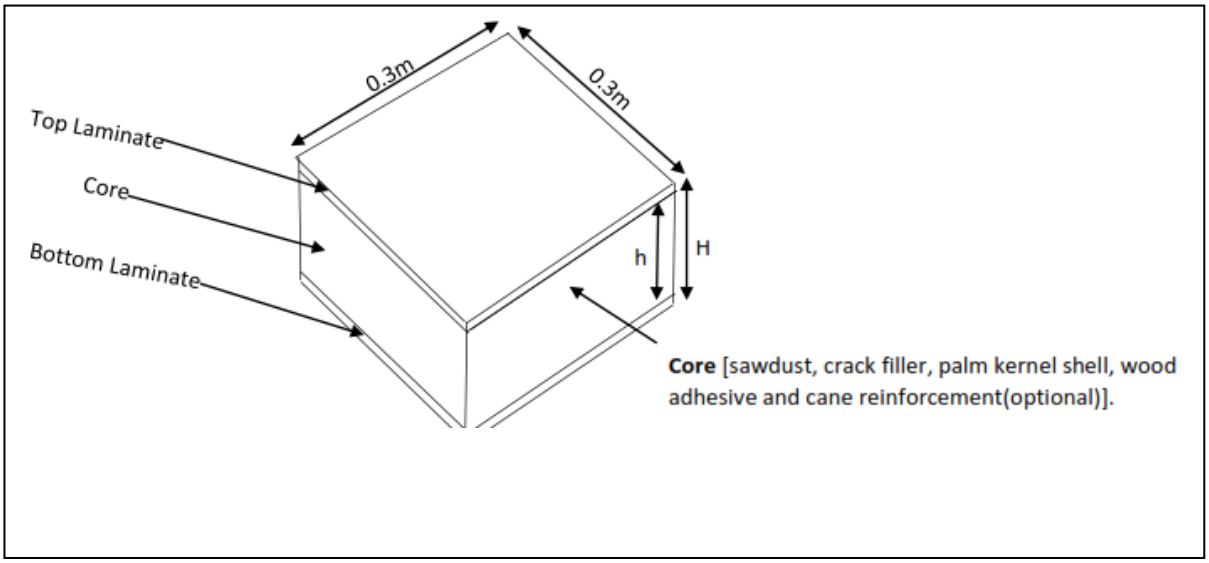

Fig. 1. Layout of Composite slab element

III. RESULTS

Results for Structural characteristics of composite slab made with sawdust, Crack-filler and wood adhesive**.**

The results of the structural characteristics of composite slab made with sawdust (SD), crack-filler (CF) and wood Adhesive (WA) are presented in Tables 1 to Table 4:

Table 1: Results on Compressive Strength values of slab core made with sawdust(SD), crackfiller(CF) and wood adhesive(WA) composite cubes

Mix ratio (WA: CF: SD)	Sample Number	Area of Sample (mm^2)	Mass of Sample (Kg)	Yield load (KN)	Compression Strength (N/mm^2)	Mean Compression strength (N/mm^2)
0.5: 0.5 : 1.5: 0.5	A	22500	4.93	334.3	14.86	14.91
0.5: 0.5 : 1.5: 0.5	B	22500	4.99	341.5	15.18	
0.5: 0.5 : 1.5: 0.5	C	22500	5.06	330.7	14.70	
0.5 : 0.75 : 1.5: 0.5	A	22500	5.29	349.56	15.54	15.78
0.5 : 0.75 : 1.5: 0.5	B	22500	5.26	352.76	15.68	
0.5 : 0.75 : 1.5: 0.5	C	22500	5.32	362.66	16.12	

Table2: Results on Dry Density of composite slab core made with sawdust(SD), crackfiller(CF) and wood adhesive(WA) composite

MIX RATIO (WA: CF: SD)	SAMPLE NUMBER	VOLUME OF SAMPLE (M^3)	MASS OF SAMPLE (KG)	DENSITY (KG/M^3)	MEAN DENSITY (KG/M^3)
0.5: 0.5 : 1.5: 0.5	A	0.003375	4.82	1428.15	1446.914
0.5: 0.5 : 1.5: 0.5	B	0.003375	4.88	1445.93	
0.5: 0.5 : 1.5: 0.5	C	0.003375	4.95	1466.67	
0.5 : 0.75 : 1.5: 0.5	A	0.003375	5.18	1534.81	1534.815
0.5 : 0.75 : 1.5: 0.5	B	0.003375	5.15	1525.93	
0.5 : 0.75 : 1.5: 0.5	C	0.003375	5.21	1543.70	

Table3: Results on Flexural Strength values of composite slab core made with sawdust (SD), crack-filler (CF) and wood Adhesive (WA) composite

TYPE	SLAB SYMBOL	MIX RATIO	THICKNESS(MM)	YIELD LOAD(KN)	FLEXURAL STRENGTH (N/MM^2)	AVERAGE STRENGTH (N/MM^2)
	AA1	0.5: 0.5 : 1.5:0.5	125	125.16	5.34	**5.34**
				125.39	5.35	
	AA2	0.5: 0.5 : 1.5:0.5	150	186.64	5.53	**5.52**
				185.96	5.51	
	AA3	0.5: 0.5 : 1.5:0.5	175	249.44	5.43	**5.40**
				249.90	5.44	
	AA4	0.5: 0.5 : 1.5:0.5	200	313.80	5.23	**5.24**
				315.00	5.25	
	AA5	0.5: 0.5 : 1.5:0.5	225	384.24	5.06	**5.06**
				383.48	5.05	
	AB1	0.5: 0.75 : 1.5:0.5	125	128.44	5.48	**5.49**
				128.91	5.50	
	AB2	0.5: 0.75 : 1.5:0.5	150	186.98	5.54	**5.55**
				187.65	5.56	
	AB3	0.5: 0.75 : 1.5:0.5	175	248.52	5.41	**5.42**
				249.44	5.43	
	AB4	0.5: 0.75 : 1.5:0.5	200	315.60	5.26	**5.25**
				314.40	5.24	
	AB5	0.5: 0.75 : 1.5:0.5	225	386.52	5.09	**5.08**
				385.00	5.07	

Table 4: Results on Deflection values of composite slab core made with sawdust (SD), crack- filler (CF) and wood Adhesive (WA) composite

SLAB SYMBOL	MIX RATIO	THICKNESS (MM)	YIELD LOAD(KN)	FLEXURAL STRENGTH(N/MM^2)	DEFLECTION (MM)	AVERAGE DEFLECTION
AA1	0.5: 0.5 : 1.5:0.5	125	125.16	5.34	87.2	**86.5**
			125.39	5.35	85.8	
AA2	0.5: 0.5 : 1.5:0.5	150	186.64	5.53	74.2	**74.9**

			185.96	5.51	75.6	
AA3	0.5: 0.5 : 1.5:0.5	175	249.44	5.43	51.2	**50.95**
			249.90	5.44	50.7	
AA4	0.5: 0.5 : 1.5:0.5	200	313.80	5.23	33.4	**34**
			315.00	5.25	34.6	
AA5	0.5: 0.5 : 1.5:0.5	225	384.24	5.06	29.3	**28.95**
			383.48	5.05	28.6	
AB1	0.5: 0.75 : 1.5:0.5	125	128.44	5.48	30.2	**30.95**
			128.91	5.50	31.7	
AB2	0.5: 0.75 : 1.5:0.5	150	186.98	5.54	44.6	**44.15**
			187.65	5.56	43.7	
AB3	0.5: 0.75 : 1.5:0.5	175	248.52	5.41	50.9	**50.7**
			249.44	5.43	50.5	
AB4	0.5: 0.75 : 1.5:0.5	200	315.60	5.26	39.9	**40.05**
			314.40	5.24	40.2	
AB5	0.5: 0.75 : 1.5:0.5	225	386.52	5.09	29.6	**29.85**
			385.00	5.07	30.1	

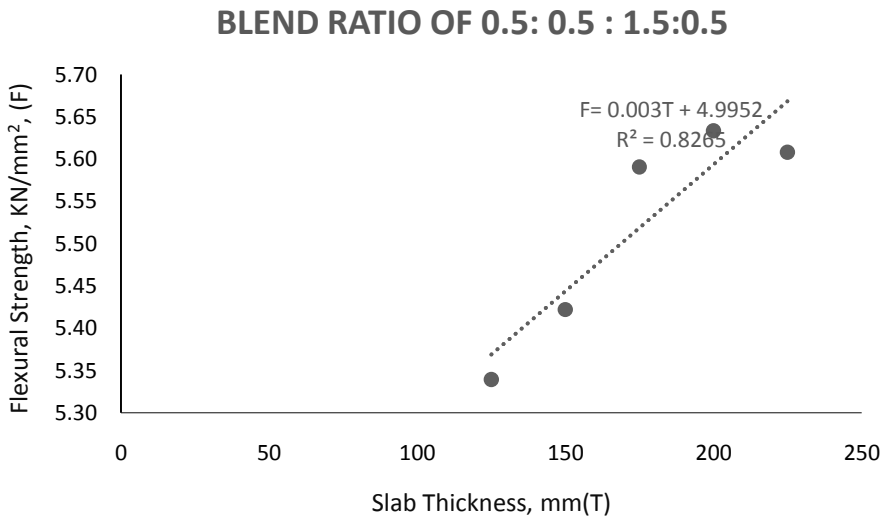

Fig. 2. Straight-line graph of Flexural strength of composite slab against Slab thickness using0.5: 0.5 : 1.5:0.5blend ratio

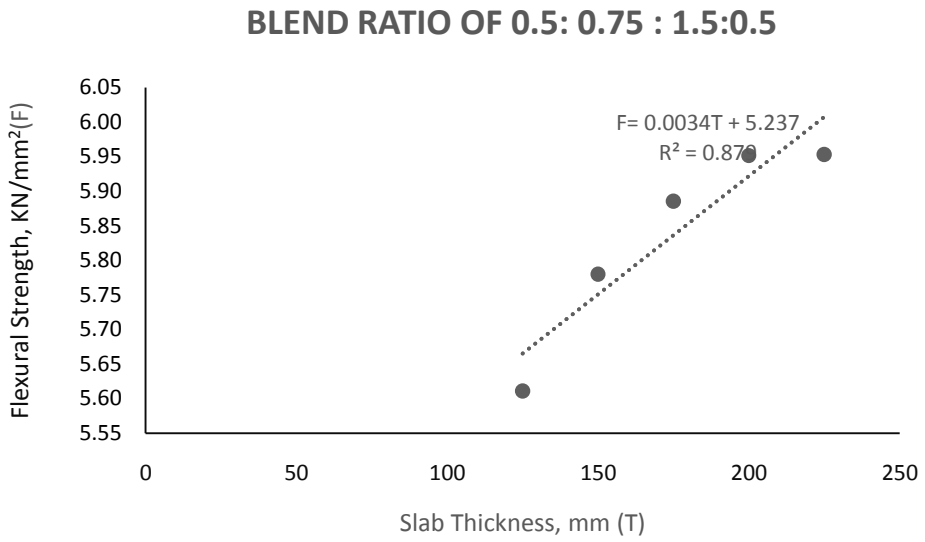

Fig. 3. Straight-line graph of Flexural strength of composite slab against Slab thickness using 0.5: 0.75 : 1.5:0.5blend ratio

IV. DISCUSSION &CONCLUSION

The mean compressive strength of slab were 14.91MPa and 15.78MPa for mix ratio 0.5: 0.5 : 1.5:0.5 and 0.5: 0.75 : 1.5:0.5 respectively. The values obtained are about 25.2% and 29.3% respectively greater than the mean compressive value of the timber veneer specie (AfaraDudu wood specie) varying from 10.2 – 12.01MPa for structural purposes. The average density of slab were 1446.914 Kg/m³ and 1534.815 Kg/m³ for mix ratio 0.5: 0.5 : 1.5:0.5 and 0.5: 0.75 : 1.5:0.5 respectively. Themean flexural strengthof Slab for both mix ratio 0.5: 0.5 : 1.5:0.5 and 0.5: 0.75 : 1.5:0.5 failed lower than the allowable limit of the timber veneer and that of light weight element. The highest bending strength were recorded on 150mm thick slab for both mix ratios while the least bending strength were recorded on 225mm thick slab for both mix ratios.From Table 4, the average deflection of slab ranged from 28.9mm to 86.5mm for mix ratio 0.5: 0.5 : 1.5:0.5 and 29.85mm to 50.7mm for mix ratio 0.5: 0.75 : 1.5:0.5. The highest deflection were recorded on 125mm thick slab for mix ratio 0.5: 0.5 : 1.5:0.5 and on 175mm thick slab for 0.5: 0.75 : 1.5:0.5 while the lowest deflection were recorded on 225mm thick slab for both blend ratios.

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