International Journal of Science and Advanced Innovative Research
ISSN: 2536-7315 (Print) 2536-7323 (Online)
Volume 6, Number 2, June 2021
http://www.casirmediapublishing.com

EVALUATION OF SAW DUST CONCRETE WITH VARIOUS PERCENTAGES OF METAKAOLIN

Gana A. J.; Ogunleye, O. D. & Braimoh S.O.
Department of Civil Engineering
Landmark University, Omu-Aran
Email: phildeb0123@gmail.com or braimohsolo@gmail.com

ABSTRACT

This study established the effects of Metakaolin on Sawdust Concrete as an additive in concrete composites. The workability density, flexural strength and compressive strength of the sawdust concrete and Sawdust Concrete with various percentages (i.e 5%, 10% and 15%) of Metakaolin were compared to that of normal mix batch conventional concrete. The mix design was based on relevant concrete mix design codes. The 150mm x 150mm x 150mm cube specimens was used for the compressive strength testing of 200mm x 100mm x 50mm rectangular Beam specimens Test for flexural strength. The specimens were cured in water and were tested after 7, 14 and 28 days. The tests showed that the workability of concrete reduces after using Sawdust as full replacement of sand and also reduces after the addition of Mekaolin in Sawdust concrete. Tests on compressive and flexural strength showed that Sawdust Concrete had light weight, but the addition of Mekaolin enhanced the strength of the concrete, although concrete strength does not increase proportionally with increasing fibre. The increased in strength was just up to a certain Metakaolin compressive and flexural strength after 28days of curing

Keywords: Strength, Evaluation, Saw-dust, Concrete, Metakaolin

INTRODUCTION

Waste materials have always been regarded by a large number of people with no knowledge as being worthless and of no use so thereby they should be disposed. Ever since man came into existence, agriculture and has always been a major source of survival and livelihood. As a result of man's concentrated engagement in agriculture due to rate of population growth and increase in standard of living, the rate at which fibre waste from wood called sawdust an industrial waste from cutting and grinding of timber in the form of fine particles is being generated is rapidly increasing, this is common in most countries both developed, underdeveloped and developing countries like Nigeria. Due to the use of this material for various reasons such as furniture making etc. In recent years there have been attempts and methods in controlling this waste product through burning and improper disposal. As stated by

(Cheremisinoff, 2003) these methods have been proven to be unsustainable and harmful to the environment as rotten agricultural wastes produces methane and leachate, and burning of these wastes leads to the release of CO_2 and other particulates. As a result of this; in recent years' various research works have been conducted to study and monitor how these agricultural wastes can best be effectively reused in the production of other materials. In this study, the use of sawdust as partial replacement for sand in concrete production and also replacing cement with metakaolin as a binding agent in production of concrete composites were used.

MATERIALS AND METHODS

Materials: The materials used in this study are: water, cement, Metakaolin, Sawdust, Fine aggregate and coarse aggregates.

Methods: The sample of materials for the study was prepared in accordance with a standard body. The quantity of each material was measured and weighed, while the mixing of concrete was done manually, Batching carried out by volume for sawdust. The curing of concrete was done in a curing tank filled of water at a controlled temperature of 20-25^{o}c. The Laboratory Tests carried out on the concrete are the following:-

(**i**) Specific gravity
(**ii**) Moisture content
(**iii**) Sieve analysis
(**iv**) Abrasion test
(**v**) Impact test
(**vi**) XER test

Slump test, compaction factor test, compressive strength and flexural strength tests were also carried out in order to ascertain the adequacy of the results for analysis.

RESULTS AND DISCUSSION

Specific Gravity

The specific gravity was performed to determine the density of the supplementary cementitious material, fine aggregate, coarse aggregate and sawdust. Table 4.1, Table 4.2, Table 4.3 and 4.4 shows the result of the specific gravity test carried out on fine aggregate, sawdust and metakaolin

Table 4.1 Specific gravity test result for fine aggregate

Sample	Weight (g)
Weight of pycnometer	19.5
Weight of pycnometer + sample	35.5
Weight of pycnometer + wet sample	82.5
Weight of pycnometer + water	72.5
Specific Gravity (GS)	2.67

Table 4.2 Specific gravity test result for sawdust

Sample	Weight (g)
Weight of pycnometer	19.5
Weight of pycnometer + sample	41.5
Weight of pycnometer + wet sample	66.5
Weight of pycnometer + water	60.0
Specific Gravity (GS)	1. 41

Table 4.3 Specific gravity of Metakaolin

Sample	Weight (g)
Weight of pycnometer	19.5
Weight of pycnometer + sample	34.5
Weight of pycnometer + wet sample	81.0
Weight of pycnometer + water	72.50
Specific Gravity (GS)	2. 15

Table 4.4 Specific gravity of Cement

Sample	Weight (g)
Weight of pycnometer	19.5
Weight of pycnometer + sample	34.0
Weight of pycnometer + wet sample	79.00
Weight of pycnometer + water	67.00
Specific Gravity (GS)	2.50

Moisture Content

Table 4.3 shows the result of the moisture content carried out on fine aggregate sample

Table 4.5 moisture content test result for sawdust

Sample	Weight (g)
Weight of container W_1	22.5
Weight of container+ wet sample W_2	144.5
Weight of container + dry sample W_3	138.5
Weight of dry soil	116
Moisture content w (%)	5.17

Sieve Analysis

The sieves were then separated and the weight of the metakaolin, fine aggregate and sawdust retained and passing through each sieve was carefully tabulated. Table 4.6 to Table 4.8 shows the result of the sieve analysis carried out on fine aggregate and sawdust respectively which are then represented graphically in Figure 4.1 and Figure 4.2

Table 4.6 sieve analysis for fine aggregate

Sieve Number	Diameter (mm)	Mass of Sieve (g)	Mass of Sieve & Soil (g)	Soil Retained (g)	Soil Retained (%)	Soil Passing (%)
	4.750	**530.0**	**530.0**	**0.00**	**0**	**100**
	2.000	525.5	632	106.50	10.7	89.4
	1.180	494.0	608	114.00	11.4	78.0
	0.600	477.0	929	452.00	45.2	32.8
	0.425	454.0	546	92.00	9.2	23.6
	0.300	449.0	552	103.00	10.3	13.3
	0.212	420.0	472.5	52.50	5.3	8.0
	0.150	402.0	432	30.00	3.0	10.3
	0.075	367.0	384	17.00	1.7	8.5
	0.063	381.5	383	1.50	0.2	8.4
Pan	0.055	389.0	390	1.00	0.1	0.0
			TOTAL:	**969.50**	**97.0**	

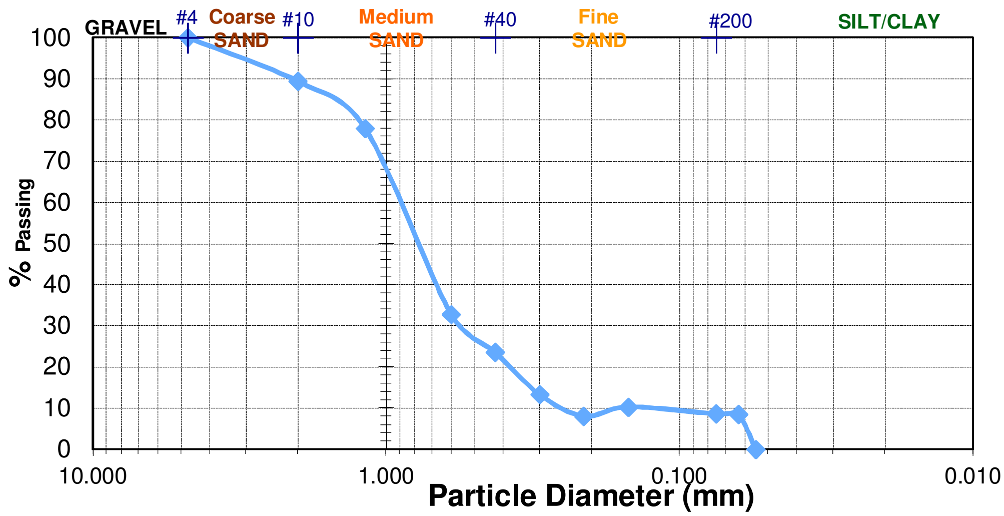

Fig 4.1 Sieve analysis for fine aggregate

Table 4.7 sieve analysis for sawdust

Sieve Number	Diameter (mm)	Mass of Sieve (g)	Mass of Sieve & Soil (g)	Soil Retained (g)	Soil Retained (%)	Soil Passing (%)
	4.750	530.0	530.0	0.00	0	100
	2.000	525.5	536	10.50	1.1	99.0
	1.180	494.0	515.5	21.50	2.2	96.8
	0.600	477.0	635.5	158.50	15.9	81.0
	0.425	454.0	479.5	25.50	2.6	78.4
	0.300	449.0	467	18.00	1.8	76.6
	0.212	420.0	431	11.00	1.1	75.5
	0.150	402.0	416.5	14.50	1.5	75.2
	0.075	367.0	372.5	5.50	0.6	74.6
	0.063	381.5	382.5	1.00	0.1	74.5
Pan	0.055	389.0	393.5	4.50	0.5	0.0
			TOTAL:	270.50	27.1	

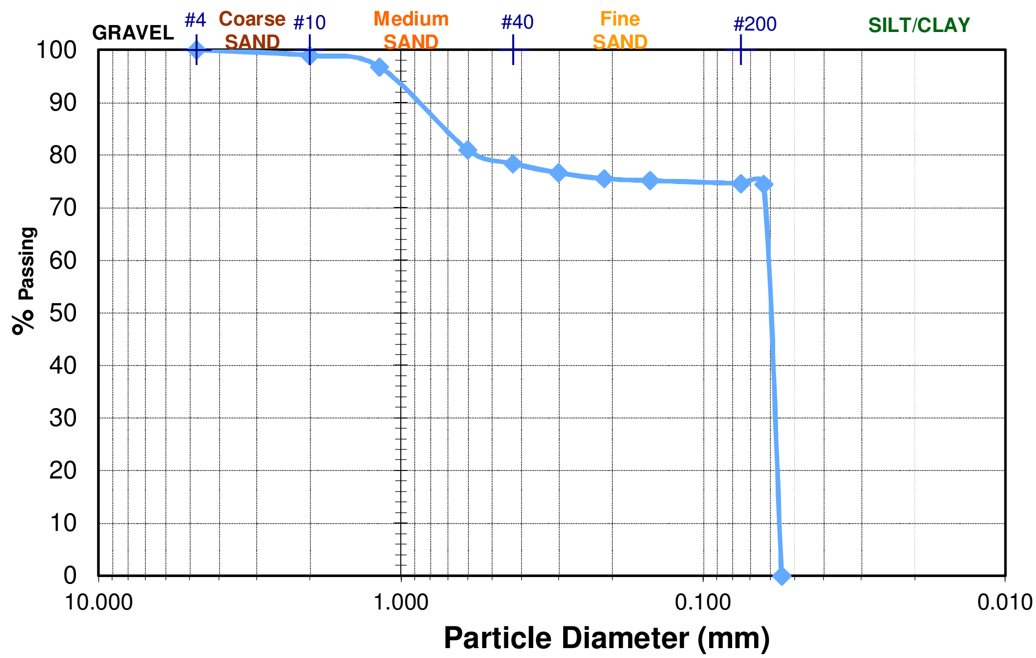

Fig 4.2 Sieve analysis for sawdust

Table 4.8 sieve analysis for Metakaolin

Sieve Size (mm)	Weight of Soil Retained on Sieve (g)	Weight of Sieve(g)	Weight of soil Retained (g)	Weight of Soil Passing (g)	Percentage Retained (%)	Percentage Passing (%)
2.000	518.50	517.00	1.50	94.00	1.57	98.43
1.180	490.50	490.00	0.50	93.50	0.52	97.91
0.600	473.50	473.50	0.00	93.50	0.00	97.91
0.425	455.50	452.50	3.00	90.50	3.14	94.76
0.300	446.50	435.00	11.50	79.00	12.04	82.72
0.212	437.50	409.00	28.50	50.50	29.84	52.88
0.150	430.00	398.00	32.00	18.50	33.51	19.37
0.075	380.50	369.00	11.50	7.00	12.04	7.33
Pan	394.50	387.50	7.00	0.00	7.33	0.00

International Journal of Science and Advanced Innovative Research
ISSN: 2536-7315 (Print) 2536-7323 (Online)
Volume 6, Number 2, June 2021
http://www.casirmediapublishing.com

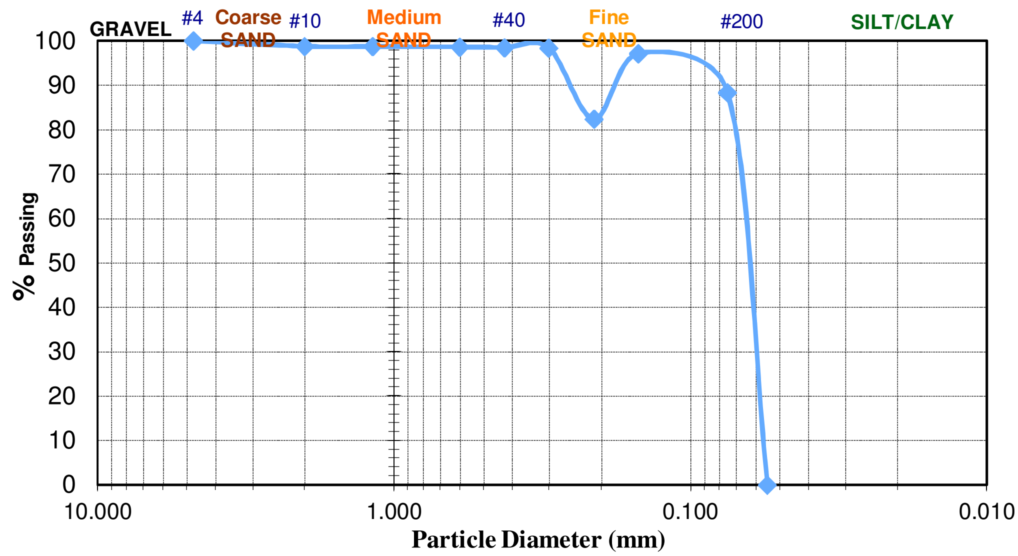

Fig 4.3 Sieve analysis for metakaolin

Impact Test

Table 4.6 shows the result of the impact test carried out on coarse aggregate sample.

Table 4.9 impact test for coarse aggregate

Sample	Weight (g)
Weight of container W_1	2994.5
Weight of container + sample W_2	3560
Mass of sample passing through 2.36mm sieve (g)	112.0
AIV (%)	19.8

Abrasion Test

Table 4.7 shows the result of the abrasion test carried out on coarse aggregate sample.

Table 4.10 abrasion test for coarse aggregate

Sample	Weight (g)
Weight of sample (g)	3000
Mass of sample retained on 2mm sieve (g)	1985.5
AAV (%)	33.8

Slump Test

Table 4.1 shows the result of the slump tests for each mixed concrete batch for both cube and beam. The slump is measured in millimetres.

Table 4.11 Slump test result

Batch	Slump (mm)
Nominal mix	65
Sawdust concrete	48
5% MK	34
10% MK	26
15% MK	17

The results in Table 4.1 show that the workability of the freshly mixed concrete does not fall within the mix design range (30 – 60mm). It can also be observed that the elimination of sand and using sawdust completely reduces the workability of concrete while the addition metakaolin also reduces effectively the workability of the concrete. To achieve a more workable sawdust concrete, the water-cement ratio may need to be increased and. Fig. 4.3 gives a graphical representation of the slump test results.

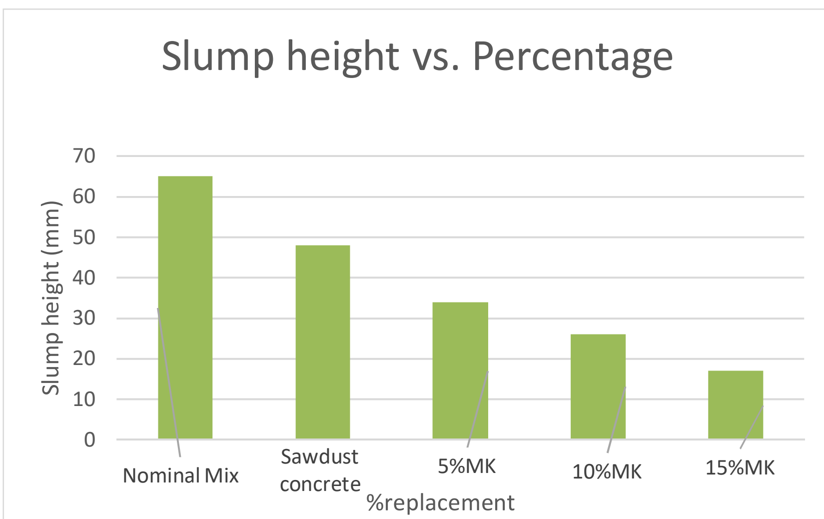

Fig. 4.3 Slump height vs. percentage replacement

Compaction Factor Test

Table 4.2 shows the results obtained during the compacting factor test on the fresh concrete

International Journal of Science and Advanced Innovative Research
ISSN: 2536-7315 (Print) 2536-7323 (Online)
Volume 6, Number 2, June 2021
http://www.casirmediapublishing.com

Table 4.12 Compaction Factor test result

Batch	Compaction Factor
Nominal mix	0.5
Sawdust concrete	1.1
5% MK	2.1
10% MK	2.5
15% Fibre	2.9

The result of the compaction factor test shows that the control batch has the lowest workability when compared with the other mix batches. It can be concluded that the addition of the elimination of sand and replacing with sawdust increase the workability of concrete while the addition of metakaolin in sawdust concrete also gives a significant increase in the workability of mixed concrete. Plate. 4.2 gives a graphical representation of the compaction test results.

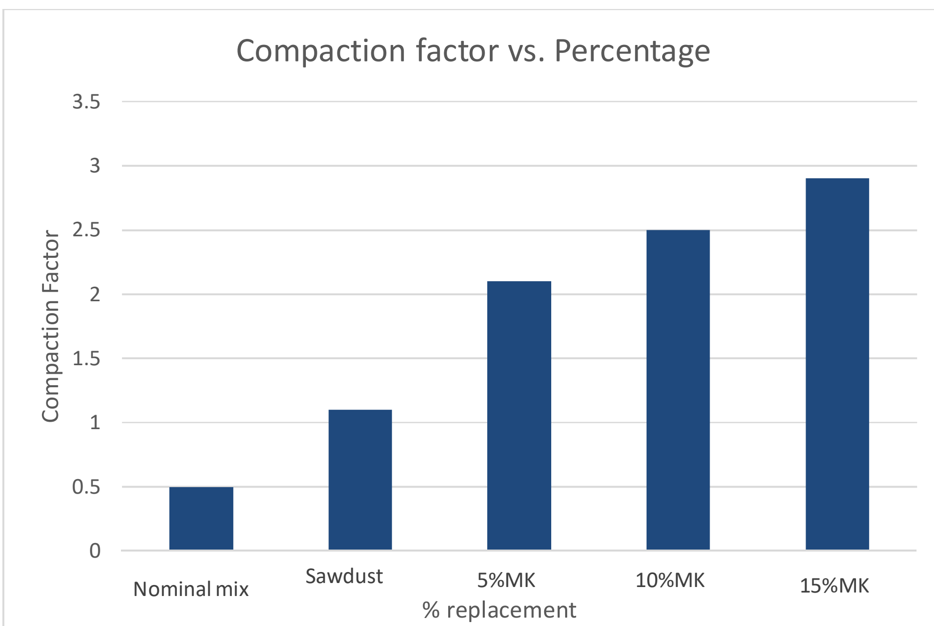

Fig. 4.3 Compaction factor vs. percentage replacement

XRF Analysis

The XRF analysis done on metakaolin yielded the results as shown in table 4.3, from Table 4.3 the concentration of SiO_2, Al_2o3 and Fe_2O_3 are

46.87%, 34.50% and 3.08% respectively. The addition of the three gives a total of 84.45% which is greater than 70%. Therefore, metakaolin is a pozzolanic material

Table 4.13 XRF Analysis test result

Sample Table

Layer	Component	Type	Concn.	Error	Units	Mole%	Error
1	SiO2	Calc	46.873	0.749	wt.%	55.961	0.894
1	V2O5	Calc	0.114	0.008	wt.%	0.045	0.003
1	Cr2O3	Calc	0.022	0.004	wt.%	0.010	0.002
1	MnO	Calc	0.068	0.004	wt.%	0.068	0.004
1	Fe2O3	Calc	3.076	0.017	wt.%	1.382	0.008
1	Co3O4	Calc	0.014	0.005	wt.%	0.004	0.002
1	NiO	Calc	0.004	0.002	wt.%	0.004	0.002
1	CuO	Calc	0.023	0.002	wt.%	0.021	0.002
1	Nb2O3	Calc	0.010	0.002	wt.%	0.003	0.001
1	MoO3	Calc	0.002	0.003	wt.%	0.001	0.002
1	WO3	Calc	0.000	0.000	wt.%	0.000	0.000
1	P2O5	Calc	0.020	0.151	wt.%	0.010	0.076
1	SO3	Calc	0.808	0.058	wt.%	0.724	0.052
1	CaO	Calc	11.065	0.080	wt.%	14.154	0.102
1	MgO	Calc	0.000	0.000	wt.%	0.000	0.000
1	K2O	Calc	0.766	0.027	wt.%	0.583	0.021
1	BaO	Calc	0.000	0.000	wt.%	0.000	0.000
1	Al2O3	Calc	34.501	1.601	wt.%	24.273	1.126
1	Ta2O5	Calc	0.015	0.007	wt.%	0.002	0.001
1	TiO2	Calc	1.911	0.024	wt.%	1.716	0.022
1	ZnO	Calc	0.046	0.002	wt.%	0.041	0.002
1	Ag2O	Calc	0.016	0.017	wt.%	0.005	0.005
1	Cl	Calc	0.425	0.022	wt.%	0.860	0.044
1	ZrO2	Calc	0.187	0.004	wt.%	0.109	0.002
1	SrO	Calc	0.035	0.002	wt.%	0.024	0.001

Element Table

Elmt	Line Code	Cond Code	Ratio Method	Intensity (c/s)	Error (c/s)	Intensity Method	Conc.	Conc Method	Calibration Coefficient
O	Ka	0	None	0.000	0.0000	Gaussian	46.827	None	0.000
Mg	Ka	1	None	0.000	2.6787	Gaussian	0.000	FP	0.000
Al	Ka	1	None	155.092	7.1955	Gaussian	18.260	FP	0.000
Si	Ka	1	None	725.478	11.5882	Gaussian	21.911	FP	0.000
P	Ka	1	None	0.730	5.4563	Gaussian	0.009	FP	0.000
S	Ka	1	None	52.476	3.7530	Gaussian	0.324	FP	0.000
Cl	Ka	1	None	92.093	4.7595	Gaussian	0.425	FP	0.000
K	Ka	1	None	212.839	7.6192	Gaussian	0.636	FP	0.000
Ca	Ka	1	None	3882.453	27.9254	Gaussian	7.908	FP	0.000
Ti	Ka	1	None	1018.157	12.8724	Gaussian	1.145	FP	0.000
V	Ka	1	None	77.466	5.3043	Gaussian	0.064	FP	0.000
Cr	Ka	1	None	23.333	3.8274	Gaussian	0.015	FP	0.000
Mn	Ka	1	None	101.738	5.4163	Gaussian	0.052	FP	0.000
Fe	Ka	1	None	5085.206	28.3020	Gaussian	2.151	FP	0.000
Co	Ka	1	None	28.890	10.6040	Gaussian	0.010	FP	0.000
Ni	Ka	1	None	8.737	5.4630	Gaussian	0.003	FP	0.000
Cu	Ka	1	None	65.111	5.3228	Gaussian	0.019	FP	0.000
Zn	Ka	1	None	144.418	6.5966	Gaussian	0.037	FP	0.000
Sr	Ka	1	None	118.687	6.7923	Gaussian	0.029	FP	0.000
Zr	Ka	1	None	479.097	10.0281	Gaussian	0.139	FP	0.000
Nb	Ka	1	None	23.354	5.7103	Gaussian	0.008	FP	0.000
Mo	Ka	1	None	4.719	6.3466	Gaussian	0.002	FP	0.000
Ag	Ka	1	None	4.384	4.4646	Gaussian	0.015	FP	0.000
Ba	La	1	None	0.000	11.9358	Gaussian	0.000	FP	0.000
Ta	La	1	None	11.547	5.5682	Gaussian	0.012	FP	0.000
W	La	1	None	0.000	6.9728	Gaussian	0.000	FP	0.000

Analysis Conditions

#	Target	Filter	Thick. mg/cm2	kV	uA	Detector Type	Detector Filter	Thick. mg/cm2	Atm	Preset Time(s)	Actual Time(s)
1	Rh	None	0.00	30.0	40.0	SDD	None	0.00	Air	60.0	60.0

Processing Conditions

#	No. Smths	Escape Peaks	Sum Peaks	Back Type	C/R Ratio	Blank Rem.	Blank File
1	1	Yes	Yes	Auto	No	No	

Concrete Density Test

The mass of all test cubes was measured, and the average unit weight (density) of each concrete batch was calculated based on the BS EN 323 (1993) code and shown in Table 4.3.

$$Density\ (kg/m^3) = {}^{mass}/_{volume}$$

International Journal of Science and Advanced Innovative Research
ISSN: 2536-7315 (Print) 2536-7323 (Online)
Volume 6, Number 2, June 2021
http://www.casirmediapublishing.com

Table 4.14 Density of concrete cubes

Batch	Cube No.	Mass (kg)	Volume $\times 10^{-3}$ (m^3)	Density (kg/m^3)	Average Density (kg/m^3)
Nominal mix	Cube 1	7.89	3.375	2337.8	**2353.3**
	Cube 2	8.03	3.375	2379.3	
	Cube 3	7.89	3.375	2337.8	
	Cube 4	7.75	3.375	2296.3	
	Cube 5	8.22	3.375	2435.6	
	Cube 6	8.13	3.375	2408.9	
Sawdust concrete	Cube 1	6.89	3.375	2041.5	**2056.2**
	Cube 2	6.90	3.375	2044.4	
	Cube 3	6.90	3.375	2044.4	
	Cube 4	6.80	3.375	2014.8	
	Cube 5	7.10	3.375	2103.7	
	Cube 6	7.05	3.375	2088.9	
5% MK	Cube 1	6.75	3.375	2000.0	**2120.4**
	Cube 2	7.19	3.375	2130.3	
	Cube 3	7.18	3.375	2127.4	
	Cube 4	7.36	3.375	2180.7	
	Cube 5	7.32	3.375	2168.9	
	Cube 6	7.30	3.375	2162.9	
10% MK	Cube 1	7.00	3.375	2263.7	**2204.8**
	Cube 2	6.96	3.375	2168.8	
	Cube 3	7.55	3.375	2180.7	
	Cube 4	7.59	3.375	2225.1	
	Cube 5	7.31	3.375	2139.2	
	Cube 6	7. 45	3.375	2251.8	
15% MK	Cube 1	7.64	3.375	2074.0	**2165.9**
	Cube 2	7.32	3.375	2062.2	
	Cube 3	7.36	3.375	2237.0	
	Cube 4	7.51	3.375	2248.9	
	Cube 5	7.22	3.375	2165.9	
	Cube 6	7.60	3.375	2207.4	

The test results above clearly show that the density of the nominal mix batch is 2353.3kg/m^3 this value is relatively close to the density of the design mix which is 2360kg/m^3. It can also be seen that the 10% metakaolin in sawdust concrete batch yielded the highest density at 2204.8kg/m^3, and the sawdust concrete batch gave the least density value at 2056.2kg/m^3.

Fig. 4.3 shows a bar chart relating the average density to the percentage of metakaolin in sawdust concrete.

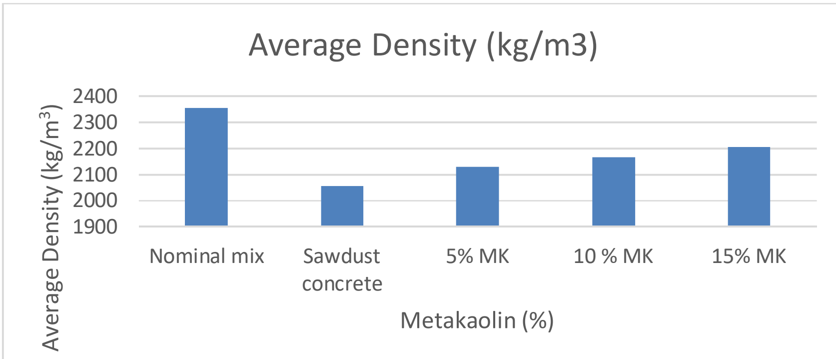

Fig. 4.4 Concrete average density vs. metakaolin %

Flexural Strength Test

The flexural strength of a total of 30 beam specimens as described in chapter three were tested. Two beams from each mix batch were tested after 7, 14, and 28 days of curing. The modulus of rupture (MOR) was calculated using the formula below.

$$\text{Modulus of Rupture } f_b\ (N/mm^2) = \frac{3Pl}{2bd^2} \quad \text{(BS 12390-5:2009)}$$

Where $P =$ maximum load (N)

$L =$ distance between supporting rollers (200mm)

$b =$ width of beam (100mm)

$d =$ depth of beam 50(mm)

The results of the flexural strength test for 7, 14, and 28 days are shown in Tables 4.4 to 4.6.

Table 4.15 Flexural strength test results at 7 days

Batch / Beam No.		Maximum load (P) (kN)	MOR (N/mm^2)	Average MOR (N/mm^2)
Nominal mix	Beam 1	13.0	3.90	3.81
	Beam 2	12.0	3.72	

Sawdust Concrete	Beam 1	8.0	1.21	1.45
	Beam 2	6.0	1.70	
5% MK	Beam 1	6.0	1.70	1.80
	Beam 2	7.0	1.90	
10% MK	Beam 1	8.0	2.45	2.49
	Beam 2	9.0	2.52	
15% MK	Beam 1	7.0	1.90	1.95
	Beam 2	6.0	1.70	

Table 4.16 Flexural strength test results at 14 days

Batch / Beam No.		Maximum load (P) (kN)	MOR (N/mm²)	Average MOR (N/mm²)
Nominal mix	Beam 1	14.0	4.60	4.48
	Beam 2	12.0	4.36	
Sawdust Concrete	Beam 1	7.0	1.90	1.90
	Beam 2	7.0	1.90	
5% MK	Beam 1	7.0	1.90	1.93
	Beam 2	5.0	1.95	
10% MK	Beam 1	8.0	2.56	2.56
	Beam 2	8.0	2.56	
15% MK	Beam 1	6.0	2.00	2.26
	Beam 2	9.0	2.52	

Table 4.17 Flexural strength test results at 28 days

Batch / Beam No.		Maximum load (P) (kN)	MOR (N/mm²)	Average MOR (N/mm²)
Nominal mix	Beam 1	16.0	5.42	5.35
	Beam 2	15.0	5.29	
Sawdust Concrete	Beam 1	9.0	2.56	2.54
	Beam 2	8.0	2.52	
5% MK	Beam 1	9.0	2.56	2.69
	Beam 2	11.0	2.82	
10% MK	Beam 1	12.0	3.72	3.27
	Beam 2	11.0	2.82	
15% MK	Beam 1	10.0	2.75	2.79
	Beam 2	11.0	2.82	

From the results given in Table 4.4 to 4.6 it can be seen that the gain of flexural strength of concrete is low at the initial stages (7 days) for all batches. The flexural strength of the concrete increases with the age of the concrete. The experiment shows that the replacement of fine aggregate with sawdust to get sawdust concrete reduces the flexural strength but the addition of the metakaolin increases the flexural strength, although the strength does not increase linearly with the increase in metakaolin percentage for sawdust concrete. Though all sawdust concrete batches containing metakaolin gave lower flexural strength than the control batch, the 10% metakaolin batch yielded the highest value of flexural strength after 7, 14, and 28 days. This results shows that the optimum metakaolin content in sawdust concrete to attain maximum flexural strength is 10%. Fig. 4.4 is a chart showing the average flexural strength and percentage fibre relationship after 7, 14, and 28 days.

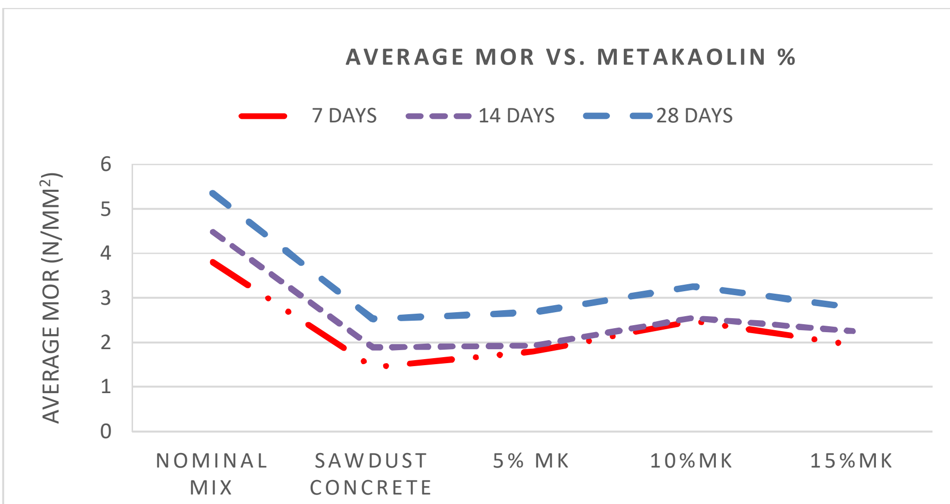

Fig. 4.4 Average MOR vs. metakaolin %

Compressive Strength Test

The compressive strength of a total of 30 concrete cubes as described in chapter three were tested. Two cubes from each mix batch were tested after 7, 14, and 28 days of curing. The compressive strength was calculated using the formula below.

Compressive strength f_{cu} $(N/mm^2) = \frac{P}{A}$ (BS 1881-Part 116)

where P = Maximum load applied to the specimen (N) and, *A* = Surface area in contact with the platens (mm^2).

Table 4.18 Compressive strength test results after 7 days

Batch / Cube No.		Surface Area (A) (mm^2)	Maximum load (P) (kN)	Compressive strength (N/mm^2)	Average Compressive strength (N/mm^2)
Nominal mix	Cube 1	22500	515.0	22.88	**22.95**
	Cube 2	22500	518.0	23.02	
Sawdust concrete	Cube 1	22500	105.0	4.67	**4.76**
	Cube 2	22500	109.0	4.84	
5% MK	Cube 1	22500	120.0	5.33	**5.47**
	Cube 2	22500	126.0	5.60	
10% MK	Cube 1	22500	139.0	6.17	**6.26**
	Cube 2	22500	143.0	6.35	
15% MK	Cube 1	22500	138.0	6.13	**6.02**
	Cube 2	22500	133.0	5.91	

Tables 4.7 to 4.9 show the results of the compressive strength tests after 7, 14 and 28 days.

A = Surface area in contact with the platens (mm^2).
Tables 4.7 to 4.9 show the results of the compressive strength tests after 7, 14 and 28 days.

Table 4.19 Compressive strength test results after 14 days

Batch / Cube No.		Surface Area (A) (mm^2)	Maximum load (P) (kN)	Compressive strength (N/mm^2)	Average Compressive strength (N/mm^2)
Control	Cube 1	22500	530.0	23.55	**23.71**
	Cube 2	22500	537.0	23.86	
Sawdust concrete	Cube 1	22500	111.0	4.93	**4.90**
	Cube 2	22500	114.0	5.06	
5% MK	Cube 1	22500	124.0	5.51	**5.55**
	Cube 2	22500	126.0	5.60	
10% MK	Cube 1	22500	143.0	6.35	**6.55**
	Cube 2	22500	152.0	6.75	
15% MK	Cube 1	22500	144.0	6.40	**6.28**
	Cube 2	22500	139.0	6.17	

Table 4.20 Compressive strength test results after 28 days

Batch / Cube No.		Surface Area (A) *(mm²)*	Maximum load (P) *(kN)*	Compressive strength *(N/mm²)*	Average Compressive strength *(N/mm²)*
Nominal mix	Cube 1	22500	619.8	27.55	**27.40**
	Cube 2	22500	613.4	27.26	
Sawdust concrete	Cube 1	22500	118.0	5.24	**5.22**
	Cube 2	22500	117.0	5.20	
5% MK	Cube 1	22500	129.0	5.73	**5.78**
	Cube 2	22500	131.0	5.82	
10% MK	Cube 1	22500	170.0	7.55	**7.79**
	Cube 2	22500	181.0	8.04	
15% MK	Cube 1	22500	163.0	7.24	**7.38**
	Cube 2	22500	169.0	7.51	

The results of the compressive strength test given in the above tables show clearly that the addition of the metakaolin increases the compressive strength of sawdust concrete

Table 4.7 to 4.9 shows that nominal mix batches yield compressive strength value greater than sawdust concrete and the addition of metakaolin in sawdust concrete. The results show that the optimum percentage of metakaolin in sawdust concrete to yield the maximum compressive strength is 10% (by weight of cement) as it yields 7.79N/mm², a huge difference in strength compared to the control batch after 28 days. Fig 4.5 shows a bar chart relating the average compressive strength and fibre percentage after 28 days.

International Journal of Science and Advanced Innovative Research
ISSN: 2536-7315 (Print) 2536-7323 (Online)
Volume 6, Number 2, June 2021
http://www.casirmediapublishing.com

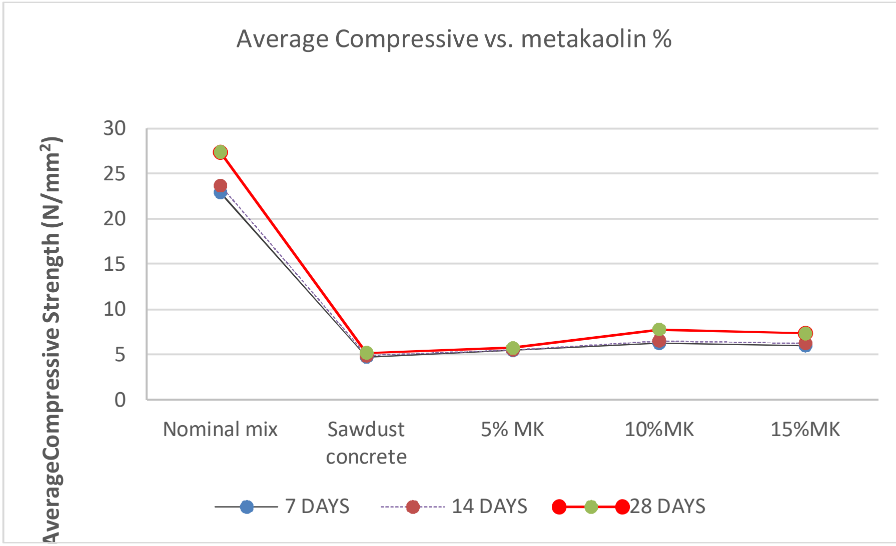

Fig. 4.4 Average Compressive vs. metakaolin %

CONCLUSION AND RECOMMENDATION

The effect of the replacement of cement with metakaolin in sawdust concrete as an additive was analysed in this study. The study is aimed at reducing the rate at which this by-product is being converted to solid waste material by effectively utilizing the sawdust gotten from sawing of wood in the production of concrete that can definitely be utilized in conditions where compressive strength is not a huge necessity and since sawdust can be obtained at little or no cost. The compressive and flexural strength characteristics of sawdust concrete were discussed and compared with conventional concrete. Based on the results and analysis, the following conclusions were drawn:

1. The workability of freshly mixed concrete reduced after sawdust was used in producing sawdust concrete and a sudden increase happened after 5% of metakaolin was used to partially replace cement and then a sudden decrease happened after 10%. This is a result of the water absorption characteristic of the sawdust which makes the mix stiffer, gives a lower slump value and affects the appearance of the concrete when it sets if not properly compacted.
2. The metakaolin percentage that yielded the highest density was 15% with 2204.8 kg/m^3 while the 5% batch yielded 2128.4 kg/m^3. The nominal mix yielded 2353.3 kg/m^3 and the sawdust concrete batch yielded 2056.2 kg/m^{3,} hence the density of the sawdust concrete increase with an

increase with an increase in metakaolin content due to the volume of voids.

3. The flexural strength values indicate that sawdust concrete gains high strength at the early stage. It also shows that the addition of metakaolin increases the modulus of rupture (MOR) after 7, 14 and 28 days although the MOR does not increase with increasing metakaolin content. The increase in MOR is only up to a certain metakaolin content. The 10% metakaolin batch yielded the highest MOR at 28 days with 3.27N/mm^2
4. Addition of metakaolin in sawdust concrete increases the compressive strength of the concrete after 7, 14 and 28 days. The 10% MK batch yielded the highest compressive strength value 7.79N/mm^2. The compressive strength does not increase with increasing metakaolin content; the increase is only up to a certain metakaolin content.
5. The optimum quantity of metakaolin for use as an additive in sawdust concrete is 10% (by weight of cement) as it yields the highest compressive and flexural strength values.

RECOMMENDATION

1. Research on the use of more industrial wastes in the production of construction materials and concrete composites should be encouraged to develop enhanced structural composites and aid in the control of agro-wastes.
2. Additives such as metakaolin should be studied further and used a lot in the construction as it is a pozzolan that has proved to be useful in improving mechanical properties of concrete.
3. For further researches, it is recommended that the study be done for a longer period of time to test the durability of the composites after 3 or 6 months as this will determine the suitability of the method in construction

REFERENCES

Ajay, V., & Rajeev, C. (2012). Effect of Micro Silica on The Strength of Concrete with Ordinary Portland Cement. *Research Journal of Engineering Sciences . ISSN Sept. Res. J. Engineering Sci, 1*(3), 2278–9472.

Al-Akhras, N. M. (2006). Durability of metakaolin concrete to sulfate attack. *Cement and Concrete Research, 36*(9), 1727–1734.

Awuchi, C. G. (2017). Industrial waste management : brief survey and advice to cottage , small and medium scale industries in uganda industrial waste management : brief survey and advice to cottage , small and medium scale industries in uganda Department of Biological and Envi. *International Journal of Advanced Academic Research | Sciences, Technology & Engineering, 3*(1), 26–30.

Brew, D. R. M., & Mackenzie, K. J. D. (2007). Geopolymer synthesis using silica fume and sodium aluminate. *Journal of Materials Science, 42*(11), 3990–3993.

British Standards Institution. *Method of normal curing of test specimens (20°C method),* BS 1881-111:1983.

British Standards Institution. *Method for determination of compressive strength of concrete cubes,* BS 1881-Part 116.

British Standards Institution. Testing Hardened Concrete. *Flexural strength of test specimens,* BS EN 12390-5:2009.

British Standards Institution. *Method for determination of flexural strength of concrete beams,* BS 1881-Part 118.

British Standards Institution. *Specification for aggregate from natural source for concrete,* BS 882 (1992)

Cheremisinoff, N. P. (2003). *Handbook of solid waste management and waste minimization technologies*. Butterworth-Heinemann.

Davidovits, J. (2008). *Geopolymer chemistry and applications*.

Dhinakaran, G., Thilgavathi, S., & Venkataramana, J. (2012). Compressive strength and chloride resistance of metakaolin concrete. *KSCE Journal of Civil Engineering, 16*(7), 1209–1217.

Dilip Kumar, Singh, S., Kumar, N., & Gupta, A. (2014). Low Cost Construction Material for Concrete as Sawdust. *Global Journal of Researches in Engineering, 14*(4), 1–5.

Ding, J. T., & Li, Z. (2002). Effects of metakaolin and silica fume on properties of concrete. *ACI Materials Journal, 99*(4), 393–398.

Gambhir, M. L. (2013). *Concrete Technology: Theory and Practice*. Tata McGraw-Hill Education.

Gruiz, K., & Klebercz, O. (2014). Environmental risk of waste and its management. *Engineering Tools for Environmental Risk Management: 1. Environmental Deterioration and Contamination-Problems and their Management, 1,* 135.

Hashim, H. B. I. N. (2008). *the Effect of Palm Oil Fiber on Concrete Properties Universiti Teknologi Malaysia Borang Pengesahan Status Tesis ♦*.

Hu, J. (2014). The implementation of waste sawdust in concrete. *Advanced Materials Research, 941–944*(December), 849–853. 9

Jayant Damodar Supe, & Dr. M.K.Gupta. (2014, November). Flexural Strength – A Measure to Control Quality of Rigid Concrete Pavements. *International Journal of Scientific & Engineering Research, 5*(11), 46-57.

Joy, A. M., Jolly, A. K., Raju, A. M., & Joseph, B. E. (2016). Partial Replacement of Fine Aggregate With Sawdust for Concrete. *International Journal For Technological Research In Engineering, 3*(9), 2439–2443.

Langer, W. (2016). Sustainability of aggregates in construction. In *Sustainability of Construction Materials* (Second Edi).

Mallick, P. K. (2007). *Fiber-reinforced composites: materials, manufacturing, and design*. CRC press.

Mohod, M. V. (2015). Performance of Polypropylene Fibre Reinforced Concrete. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 12*(1), 28–36.

Murali, G., & Sruthee, P. (2012). Experimental study of concrete with metakaolin as partial replacement of cement. *Int. J. Emerging Trends Eng. Dev, 4*(2), 344-348.

Narmatha, M., & Felixkala, D. T. (2016). Meta kaolin –The Best Material for Replacement of Cement in Concrete. *IOSR Journal of Mechanical and Civil Engineering, 13*(04), 66–71.

Nataraja P.T. (2014). *Properties of fresh and Hardened Concrete.* Vienna.

Nikhila, C. H. J., & Kumar, J. D. C. (2015). Partial Replacement of Cement With Metakaolin in High Strength Concrete. *International Journal of Engineering Research and Science & Technology, 4*(4), 336–349.

Ogunwusi, A. A. (2014). Wood Waste Generation in the Forest Industry in Nigeria and Prospects for Its Industrial Utilization. *Civil and Environmental Research, 6*(9), 62–69. Retrieved from http://www.iiste.org/Journals/index.php/CER/article/view/15450

Oikonomou, N. D. (2005). Recycled concrete aggregates. *Cement and*

Concrete Composites, *27*(2), 315–318. https://doi.org/10.1016/j.cemconcomp.2004.02.020

Oyedepo, O. J., Oluwajana, S. D., & Akande, S. P. (2014). Investigation of properties of concrete using sawdust as partial replacement for sand. *Civil and Environmental Research*, *6*(2), 35–42.

Patel, M., Patel, K., Patel, A., Prajapati, R., & Koshti, U. (2010). *Study of Sawdust Concrete Properties as Construction Materials*. *IV*(I).

S Shah, D., Shah, M. P., & Pitroda, J. (2014). Chemical Admixtures: a Major Role in Modern Concrete Materials and Technologies. *National Conference on: "Trends and Challenges of Civil Engineering in Today's Transforming World,"* (March 2014).

Sabir, B., Wild, S., & Bai, J. (2001). Metakaolin and calcined clays as pozzolans for concrete: A review. *Cement and Concrete Composites*, *23*(6), 441–454.

Sai, MInk., & Sairam KumarN, V. (2014). A Review on Use of Metakaolin in Cement Mortar and Concrete. *International Journal of Innovative Research in Science, Engineering and Technology (An ISO Certified Organization)*, *3297*(7), 14697–14701. Retrieved from www.ijirset.com

Salamak, M., Weseli, J., & Radziecki, A. (2007). Monitoring of highway bridges in areas under mining exploitation influence. *Bridge Design, Construction and Maintenance - Proceedings of the Two-Day International Conference Organised by the Institution of Civil Engineers, ICE*, 469–478. https://doi.org/10.1680/bdcam.35935.0051

Tantawi, H. (2015). Introduction to Concrete Technology. *Department of Civil Engineering, Fahad Bin Sultan University*, (April), 143–188. https://doi.org/10.13140/RG.2.1.3219.9201

Torrans, P. H., & Ivey, D. L. (1968). *Review of Literature on Air-Entrained Concrete*. 13. Retrieved from http://tti.tamu.edu/documents/103-1.pdf

Wikipedia, F. (2015). *Plasticizer*. 1–7.

Yunusa M.S. (2011). Causes of failure in compsite structural members. *Structural Engineering*, 187-194.