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EFFECT OF WASTE GLASS POWDER ON COW DUNG ASH CONCRETE

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ABSTRACT
The focus of this study is to determine the influence of the waste glass powder (WGP) on Cow Dung Ash (CDA) concrete. The CDA and WGP were used as partial replacement of cement where CDA was kept constant at 10 % while the WGP was used at 2, 4, 6, 8 and 10 %. A seven batches of concrete were produced for the curing age of 7, 14, and 28 days. After the preliminary tests the following aspect were focused on: consistency, setting time, workability and strength. The result showed that consistency increased with 10 % replacement of cement with CDA and that 6 % is the optimum content of WGP for consistency. The setting times of binder paste increased with 10 % replacement of cement with CDA and then continuously increasing with introduction of WGP at 2, 4 , 6 % replacement. However, the maximum initial and final setting times were attained at 6 % of WGP. The workability of concrete had been found to be decreased with CDA and gradually increased with the introduction of WGP as cement replacement. The compressive strength increased with 10 % replacement of cement with CDA, and then increased continuously with 2%, 4%, replacement of cement with WGP before it declined and increased to a maximum at 8 %. Thus the optimum content of WGP is 8 % and the compressive strength increased. Production of concrete from waste materials saves energy, enhance strength and conserves resources which lead to a safe sustainable environment.

Keywords: Glass Powder, Cow Dung Ash, Concrete, Consistency, Compressive strength

INTRODUCTION

Concrete is the most widely used construction material due to its ability to form any desired shape, but in general, concrete work is gradually becoming prohibitive, partly due to increasing cost of cement and the emission of green gases associated with its production. It is well accepted by everyone that concrete executes outstanding responsibilities for the construction of modern infrastructures and industrialization. Attempt has been made by various researchers to maintain the durability, strength and stability of concrete structure while also reducing the cost of production (Ojedukun et al., 2014). The cement industry has one of the highest carbon footprints which make traditional concrete unsustainable in the future. Materials such as Cow Dung Ash, Fly Ash, Slag, and Silica Fume, can be used as partial replacement for cementing material (Ojedukun, et al., 2014). So also, the consumption of cement in concrete industries has been increasing day by day to fulfill the pressing needs of infrastructure due to growing population, industrialization and urbanization. The production of cement poses environmental problems due to emission of gaseous pollutants (Mehta, 2004). Among the greenhouse gases, CO_2 contributes about 65% to global warming, the cement industry is responsible for about 6 % of all CO_2 emissions, during the production of one tons of Portland cement emits approximately 0.9 tons of CO_2 in to the atmosphere (Mehta, 2004). Therefore, there is a need to search for supplementary cementations materials for utilization as partial substitute for cement. Several researchers have used different materials like sawdust ash, rice husk ash, fly ash, granulated blast furnace slag, as partial replacement of cement in concrete (Karim et al., 2011).
In this project an attempt is made to use the cow dung ash and the waste glass powder as a partial replacement of cement in concrete. This effort can help in reducing the amount of CO_2 emissions emitted during cement production.

Cow Dung Ash is obtained from cow excreta which is dried under sunlight and subjected to burning. The ash content contains Nitrogen rich material, Potassium, Phosphorous and Calcium (Ojedukun, et al, 2014).

Being non-biodegradable in nature, glass disposal as landfill has environmental impacts and also could be expensive. Sustainable construction practice means creation and responsible management of a healthy built environment considering resource efficiency and ecology (Plessis, 2007). Being versatile and economical, concrete became prime construction material over the world, however, it has impacts on the environment (Naik, 2008). Glass is one the most versatile substances, used in many applications and in a wide variety of forms. The interest of the construction community in using waste or recycled materials in concrete is increasing because of the emphasis placed on sustainable construction. Glass is an inert material which could be recycled and used many times without changing its chemical property (Xiangming, 2012). The result of this research work will be beneficial to the entire world by providing the way of reducing the intensity of environmental pollution and global warming which are cause in the course of cement production by providing the material which can gradually substitute the cement in construction work. And provide the information on how to have an alternative binder material which is cheaper than cement. Therefore, the aim of this research is to determine the effect of waste glass powder (WGP) on cow dung ash (CDA) concrete.

MATERIALS AND METHODS

Materials

The materials used in this study included Ordinary Portland Cement (Dangote brand of Portland cement), fine aggregate (clean river sand), coarse aggregate, mixing water, cow dung ash (CDA) and waste glass powder (WGP).

Cow Dung Ash (CDA)

The cow dung was exposed to sunlight to dry in order to have dung cakes which was then subjected to burning after it was dried to have the cow dung ash which was obtained in black color. It was ensured that the ash was stored in an air tied container to protect from absorbing moisture. The ash obtained was sieved using British Standard sieve sizes of 150µm which is approximately size of cement particles.

Waste Glass Powder (WGP)

Glass is an amorphous (non-crystalline) substance, that is, a super cooled liquid. The waste broken bottles of Coca-Cola were collected from the Coca-Cola depot at Wunti market Bauchi state, the bottles were grounded in to pieces and then crushed it in to powder, the powder was sieved through British Standard sieve sizes of 150 micron sieve and glass powder was obtained in very find powder form that has the particle size approximately equal to that of cement particles.

Methods (Preliminary tests and procedures)

The test parameters as well as the experimental procedures are presented in this chapter. All test carried out in this research work were performed in accordance with appropriate British standard specifications. Nine tests were carried out in all, namely;

i. Specific gravity in accordance with BS 812: part 2: Methods of determination of Densities, 1995.
ii. Sieve analysis in accordance with BS 812: part 103: Testing Aggregates-Sieve tests 1985.
iii. Absorption test in accordance with BS 812: part 107: Method of determination of Particle Density and Water Absorption 1995.
iv. Moisture content in accordance with BS 812: part 109: Method of determination of moisture content. 1990.
v. Bulk Density in accordance with BS 812: part 2: Method of determination of Densities.
vi. Standard Consistency test of cement in accordance with BS 12:1996 Method for determination of Standard Consistency of cement.
vii. Setting time test in accordance with BS 12:1996 Method for determination of initial and final setting time of cement.
viii. Slump test in accordance with BS 1881: part 102: Method for determination of Slump, 1983.
ix. Compressive strength test in accordance with BS 1881: part 116: Methods for determination of compressive Strength, 1983

RESULTS AND DISCUSSIONS

Results

Specific Gravity Result of Aggregate

Table 1 Specific Gravity of Coarse Aggregate (Gravel)

Test	Trial 1	Trial 2	Trial 3
Weight of container +water (W_1) g	3182.0	3182.0	3182.0
Weight of container + water + sample (W_3) g	3511.0	3508.0	3507.4
Weight of empty tray (W_{TC}) g	378.6	378.6	378.6
Weight of tray + saturated surface dried sample (W_{ssd} +W_{TC}) g	896.7	895.2	895.8
Weight of tray + oven dried sample (W_{od} + W_{TC}) g	892.7	892.0	891.7
Weight of sample in water [($W_3 – W_1$) = Wa g	329.0	326.0	325.4
Weight of oven dried sample [(W_{od} + W_{TC})– W_{TC}]=W_{od} g	514.1	513.4	513.1
Weight of saturated surface dried sample [(W_{ssd} +W_{TC})–W_{TC}	518.1	516.6	517.2
Weight of water displaced by sample (W_{ssd} –Wa) g	189.1	190.6	191.8
Specific gravity,Gs = Wod/(Wssd – Wa) g	2.72	2.69	2.68
Average specific gravity, Gs g		2.70	

Table 2 Specific Gravity of Fine Aggregate (Sand)

Test	Trial 1	Trial 2	Trial 3
Weight of container + water (W_1) g	3182.0	3182.0	3182.0
Weight of container + water + sample (W_2) g	3596.6	3596.2	3599.0
Weight of empty tray (W_{TC}) g	378.5	378.5	378.5
Weight of tray + saturated surface dried sample (W_{ssd} +W_{TC}) g	1043.7	1044.6	1045.8
Weight of tray + oven dried sample (W_{od} + W_{TC}) g	1037.3	1035.9	1034.4
Weight of sample in water [($W_2 – W_1$) = Wa g	414.6	414.2	417.0
Weight of oven dried sample [(W_{od} + W_{TC})– W_{TC}] =W_{od} g	658.8	657.4	655.9
Weight of saturated surface dried sample [(W_{ssd}+W_{TC})–W_{TC}]	665.2	666.1	667.3
Weight of water displaced by sample (W_{ssd} –Wa) g	250.6	251.9	250.3
Specific gravity, Gs = Wod/(Wssd – Wa) g	2.63	2.61	2.62
Average specific gravity,Gs g		2.62	

Specific gravity: The specific gravity test was carried out in compliance with BS 812 part 2, 1973, the result obtained indicated that, specific gravity of coarse and fine aggregates came out to be 2.70 and 2.62 respectively (Table 3.1 to 3.2) which lies in the general range of specific gravity values (i.e. 2.4 to 2.9 for most normal weight concrete) (BS 812). Hence, this result is ok; otherwise, the concrete constituent will float over the water surface in the mix (BS 812).

Table 3: Sieve Analysis of fine Aggregates

Sieve Sizes	Mass retained (kg)	% Retained	% passing
3.35mm	1.7	0.34	99.66
2.36mm	7	1.40	98.26
1.18mm	22.8	4.56	93.70
600 µm	99.2	19.84	73.86
300µm	262.2	52.44	21.42
150µm	102.1	20.42	1.00
75.0µm	3.2	0.64	0.36
Pan	1.8	0.36	0.00

Total sample used = 500 g.

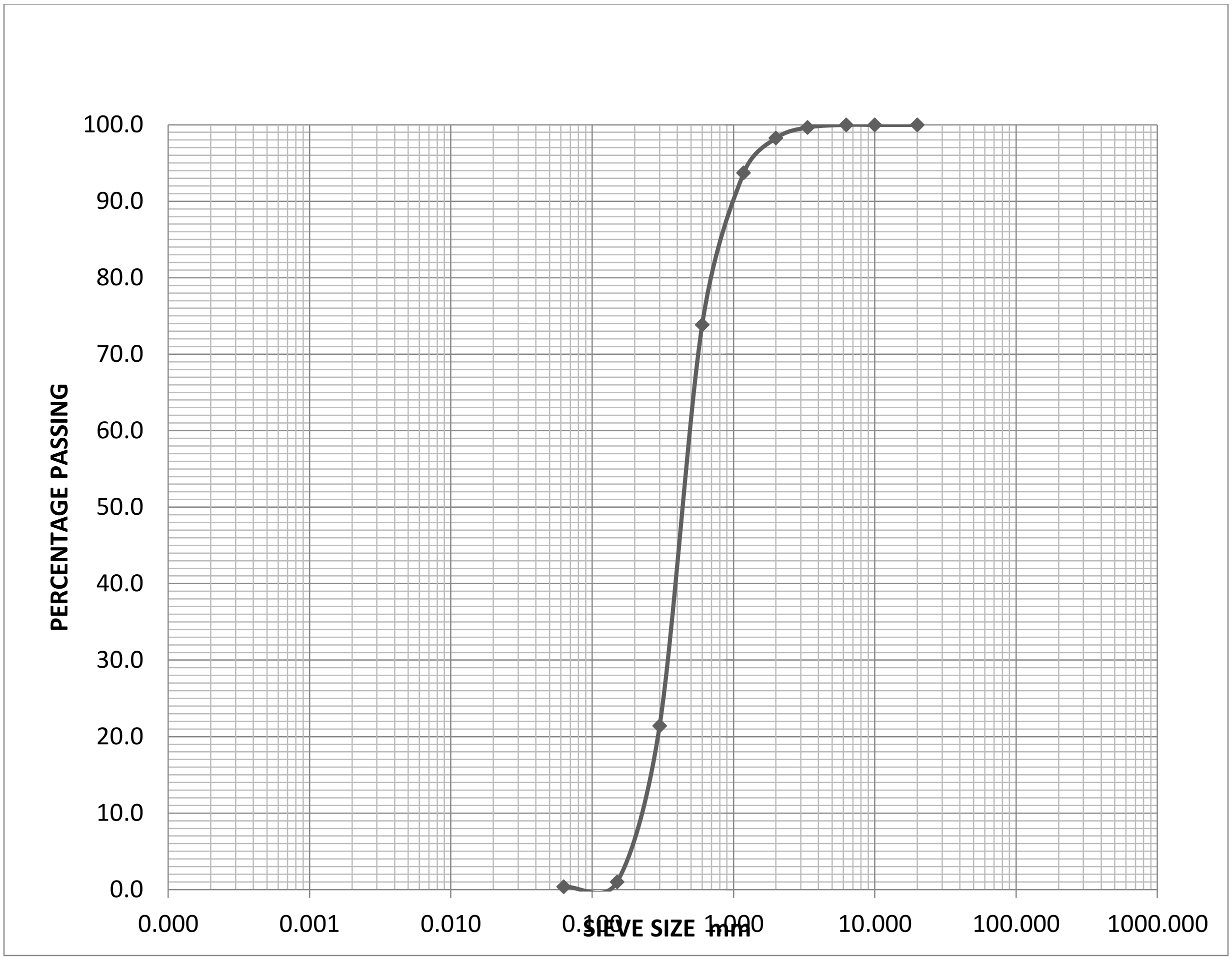

Fig. 1: Sieve analysis of fine aggregates

Table 4: Sieve Analysis of Coarse Aggregates

Sieve Sizes (mm)	Mass retained (kg)	% Retained	% passing
28	0	0	100
20	260	8.67	91.33
14	1750	58.33	33
10	600	20	13
6.3	290	9.67	3.33
5.0	40	1.33	2
Pan	60	2	0

Total sample used = 3000g.

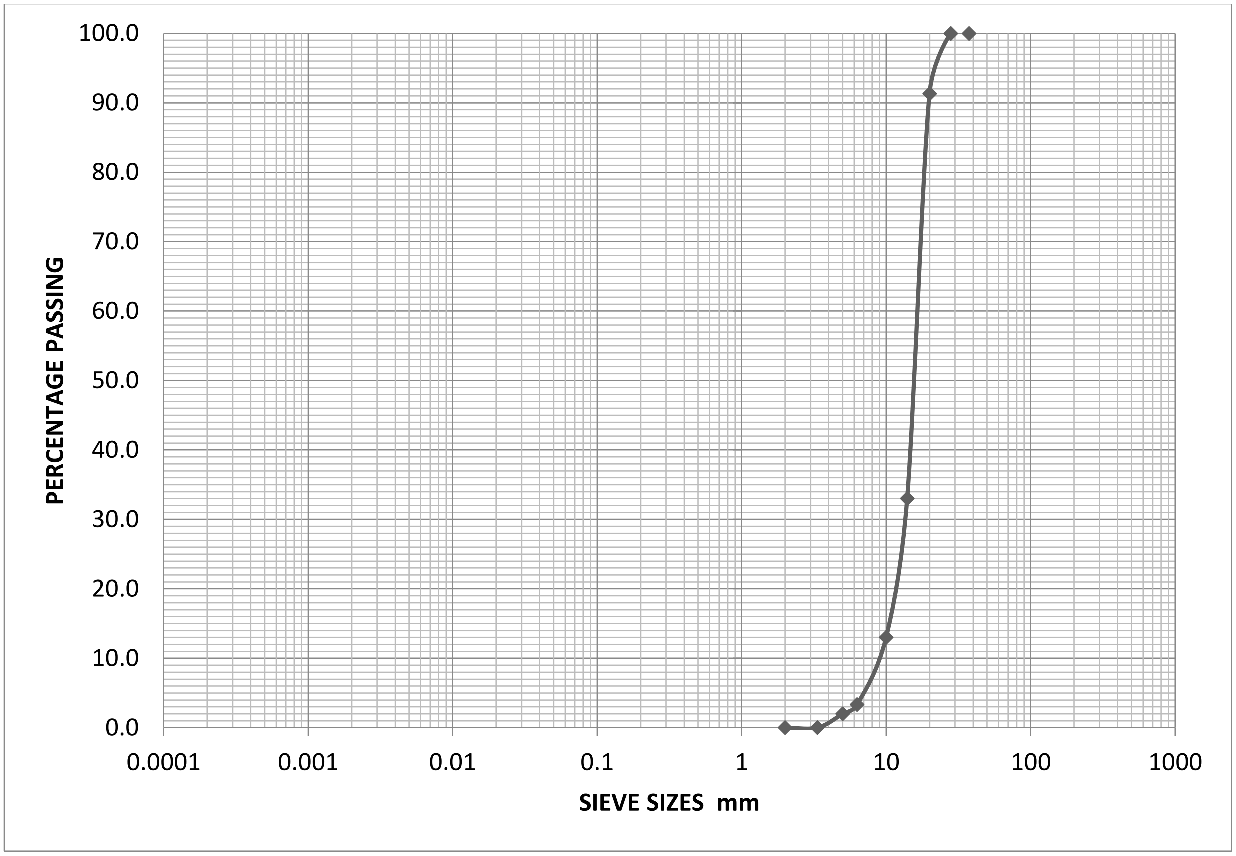

Fig. 2: Sieve analysis of coarse aggregates

In accordance with BS 812: part 103.1.1983 the result of the particle size distribution conducted on coarse and fine aggregate as shown in table 3 and 4, the graph of the particle size plotted as illustrated in figure 1 and 2 showed that the aggregate were uniformly distributed and well graded.

Water absorption of aggregate

Table 5: Results of water absorption test conducted on coarse aggregate

Test	Test1	Test2	Test3
Weight of cylinder, W_1g	378.6	378.6	378.6
Weight of cylinder + oven dried sample, $(W_{od} + W_1)$g	892.7	892.0	891.7
Weight of cylinder + saturated surface dried sample $(W_{ssd} + W_1)$g	896.7	895.2	895.8
Weight of saturated surface dried sample $(W_{ssd} + W_1) – W_1=W_{ssd}$g	518.1	516.2	517.2
Weight of oven dried sample, $(W_{od} + W_1)– W_1=W_{od}$g	514.1	513.4	513.1
Weight of water absorbed, $(W_{ssd} – W_{od})$g	04.00	02.80	04.10
Water Absorption = [(Wssd – Wod) / Wod] × 100 g	0.78	0.54	0.80
Average Water Absorption =[(0.78 + 0.54 + 0.80) / 3] = 0.71%			

Table 6: Results of water absorption test conducted on fine aggregate

Test	Test 1	Test 2	Test 3
Weight of cylinder, W_1g	378.5	378.5	378.5
Weight of cylinder + oven dried sample, $(W_{od} + W_1)$g	1037.3	1035.9	1034.4
Weight of cylinder + saturated surface dried sample $(W_{ssd} + W_1)$g	1043.7	1044.6	1045.8
Weight of saturated surface dried sample $(W_{ssd} + W_1) – W_1=W_{ssd}$g	665.2	666.1	667.3
Weight of oven dried sample, $(W_{od} + W_1)– W_1=W_{od}$g	658.8	657.4	655.9
Weight of water absorbed, $(W_{ssd} – W_{od})$g	06.40	08.70	11.40
Water Absorption = [(Wssd – Wod) / Wod] × 100 g	0.97	1.32	1.74
Average Water Absorption =[(0.97 + 1.32 + 1.74) / 3] = 1.34%			

Tables 5 and 6 above shows the Results of water absorption test conducted on coarse and find aggregates. The average water absorption of coarse aggregates and fine aggregates were found from the experiment to be 0.71 % and 1.34 % respectively, which is evidence that, these values fall within the acceptable range, water absorption value ranges from 0.1 to 2.0 % for aggregate of normal weight concrete, meaning that, the aggregates were very strength because lower water absorption means less pores, and the aggregates with less pores is considered to be very strong.

Moisture Content

Table 7: Showing results of moisture content test conducted on coarse aggregate

Can number (g)	K40	S52	F31
Weight of can, W_1, (g)	24.00	24.00	25.00
Weight of can + wet sample, W_2 (g)	109.00	100.40	94.03
Weight of wet sample, { W_2- W_1}= W_o(g)	85.00	76.40	69.03
Weight of can + oven dry sample, W_3 (g)	106.98	99.12	93.10
Weight of oven dry sample, W_d(g)	82.98	75.12	68.1
Weight of water, {W_o- W_d} = W_w,(g)	2.02	1.28	0.93
% Moisture content (M.C) = [(W_2- W_3)/ [(W_3- W_1)] ×100 % M.C= [W_w/ W_d × 100]	2.43%	1.70%	1.37%
Average moisture content = (2.43 + 1.70 + 1.37) / 3 = 1.83 %			

Table 8: Showing results of moisture content test conducted on fine aggregate

Can number (g)	E12	F2	S31
Weight of can, W_1, (g)	23.20	24.04	23.00
Weight of can + wet sample, W_2 (g)	163.00	117.30	132.41
Weight of wet sample, { W_2- W_1}= W_o(g)	139.80	93.26	109.41
Weight of can + oven dry sample, W_3 (g)	158.62	115.12	129.51
Weight of oven dry sample, W_d(g)	135.42	91.08	106.51
Weight of water, {W_o- W_d} = W_w,(g) %	04.38	2.18	2.90
Moisture content (M.C) = [(W_2- W_3)/ [(W_3- W_1)] ×100 % M.C= [W_w/ W_d × 100]	3.23%	2.39%	2.72%
Average moisture content = (3.23 + 2.39+ 2.72) / 3 = 2.78%			

Tables 7 and 8 shows the results of moisture content test conducted on coarse and fine aggregate from the result, the average moisture content obtained was 1.83% for coarse aggregates and 2.78 % for fine aggregates (Tables 7 and 8). Moisture content contributes to the mass of damp aggregate and concrete water content which makes it of great interest in mix design.

Bulk density

Table 9: Bulk density table for coarse aggregate

Measurement	Uncompacted Gravel Trial 1	Uncompacted Gravel Trial 2	Compacted Gravel Trial 1	Compacted Gravel Trial 2
Weight of empty container W_1 (kg)	10.42	10.42	10.42	10.42
Weight of container + sample W_2 (kg)	24.74	24.40	25.68	26.02
Weight of sample $(W_2 - W_1)$ (kg)	14.32	13.98	15.26	15.60
Weight of container + water W_4(kg)	20.03	20.03	20.03	20.03
Volume of container $(W_4 - W_1)$ (L)	09.61	09.61	09.61	09.61
Bulk density=$[(W_2 - W_1)/(W_4 - W_1)]$ (kg/L)	1.490	1.455	1.588	1.623
Average bulk density (kg/m^3)	1473		1606	

Table 10: Bulk density table for Fine aggregate

Measurement	Uncompacted Sand Trial 1	Uncompacted Sand Trial 2	Compacted Sand Trial 1	Compacted Sand Trial 2
Weight of empty container W_1 (kg)	10.42	10.42	10.42	10.42
Weight of container + sample W_2 (kg)	25.29	25.51	26.87	26.98
Weight of sample $(W_2 - W_1)$ (kg)	14.87	15.09	16.45	16.56
Weight of container + water W_4(kg)	20.03	20.03	20.03	20.03
Volume of container $(W_4 - W_1)$ (L)	09.61	09.61	09.61	09.61
Bulk density= $[(W_2 - W_1)/(W_4 - W_1)]$ (kg/L)	1.547	1.570	1.712	1.723
Average bulk density (kg/m^3)	1559		1718	

In his research work the bulk density determined in compliance with BS 812 indicated that, the uncompacted bulk density of coarse and fine aggregates were found to be 1473 kg/m^3 and 1559 kg/m^3 respectively, while the rodded bulk density for coarse and fine aggregates were 1606 kg/m^3 and 1718 kg/m^3 respectively (Table 9 and 10).This implies that, the aggregates were normal weight aggregates, because, the aggregate bulk density greater than 1120 kg/m^3 for light weight aggregates and were less than 2080 kg/m^3 for heavy weight aggregates So, the result was ok, since the aggregates were suitable for normal weight concrete

Porosity

Table 11: Bulk density table used to determine Porosity

Bulk density of sand	Uncompacted weight	1559 kg/m^3
	Compacted weight	1718 kg/m^3
Bulk density of gravel	Uncompacted weight	1473 kg/m^3
	Compacted weight	1606 kg/m^3

The Bulk density results above will be relevant in determining the Porosity of the materials. From the table above, result proves suitable within the specified range meaning that the cement paste can effectively fill in the minor pore spaces and promote better interlocking of the concrete components.

Void Ratio

For a quality grade concrete, it is often required that the void spaces created by coarse aggregates be filled with mortar to improve hardness and strength development and minimize honey-combing. In consonance with this, the following results were obtained from this research as void ratio for sand and gravel respectively (**0.40** and **0.45**).

Consistency

Table 12: Showing the result of consistency test conducted on cement paste

Batch ID	Standard Consistency (%)
B1 (CDA = 0% ,WGP = 0%)	29
B2 (CDA = 10% ,WGP = 0%)	31
B3 (CDA = 10% ,WGP = 2%)	31
B4 (CDA = 10% ,WGP = 4%)	31
B5 (CDA = 10% ,WGP = 6%)	31
B6 (CDA = 10%, WGP = 8%)	30
B7 (CDA = 10% ,WGP = 10%)	30

Setting time

Fig. 3: Standard consistency of binder paste

Table 13: Showing results of Initial and Final Setting Time Test conducted on cement paste

Batch ID	Initial Setting Time (Mins)	Final Setting Time (Mins)
B1 (CDA = 0% ,WGP = 0%)	49	139
B2 (CDA = 10% ,WGP = 0%)	90	194
B3 (CDA = 10%, WGP = 2%)	121	205
B4 (CDA = 10%, WGP = 4%)	130	218
B5 (CDA = 10% ,WGP = 6%)	137	227
B6 (CDA = 10% ,WGP = 8%)	100	185
B7 (CDA = 10% ,WGP = 10%)	75	150

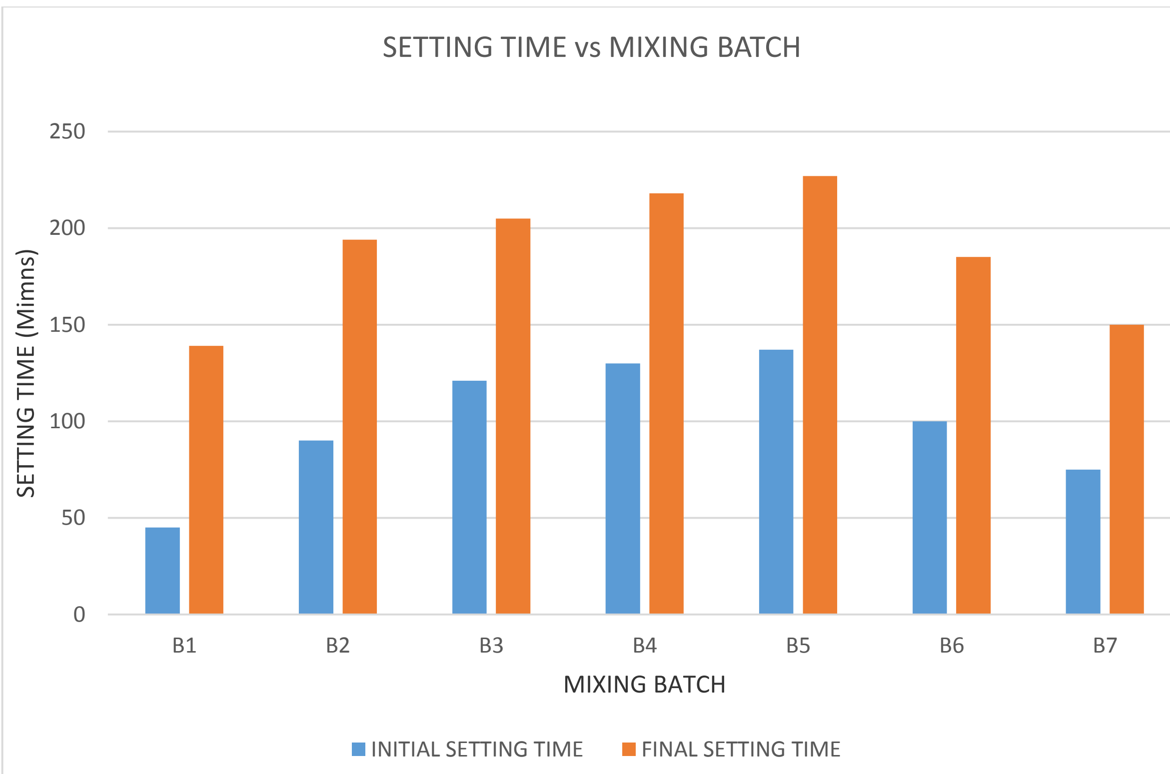

Fig. 4: Setting time of binder paste

The result of the experiment above shows that the initial and final setting time were: 49 and 139 mins for B1, 90 and 194 mins for B2, 121 and 205 mins for B3, 130 and 218 for B4, 137 and 227 mins for B5, 100 and 185 mins for B6, 75 and 150 mins for B7 respectively (table 4.13). This result implied that, the B2, B3, B4 and B5 batches which need higher amount of water to achieve maximum strength also need more time for their initial and final setting than B1, B6 and B7.

Slump

Table 14: Showing results of Slump test conducted on fresh concrete

Batch ID	Slump (mm)
B1 (CDA = 0% ,WGP = 0%)	35
B2 (CDA = 10%, WGP = 0%)	25
B3 (CDA = 10%, WGP = 2%)	30
B4 (CDA = 10% ,WGP = 4%)	45
B5 (CDA = 10%, WGP = 6%)	55
B6 (CDA = 10% ,WGP = 8%)	66
B7 (CDA = 10%, WGP = 10%)	72

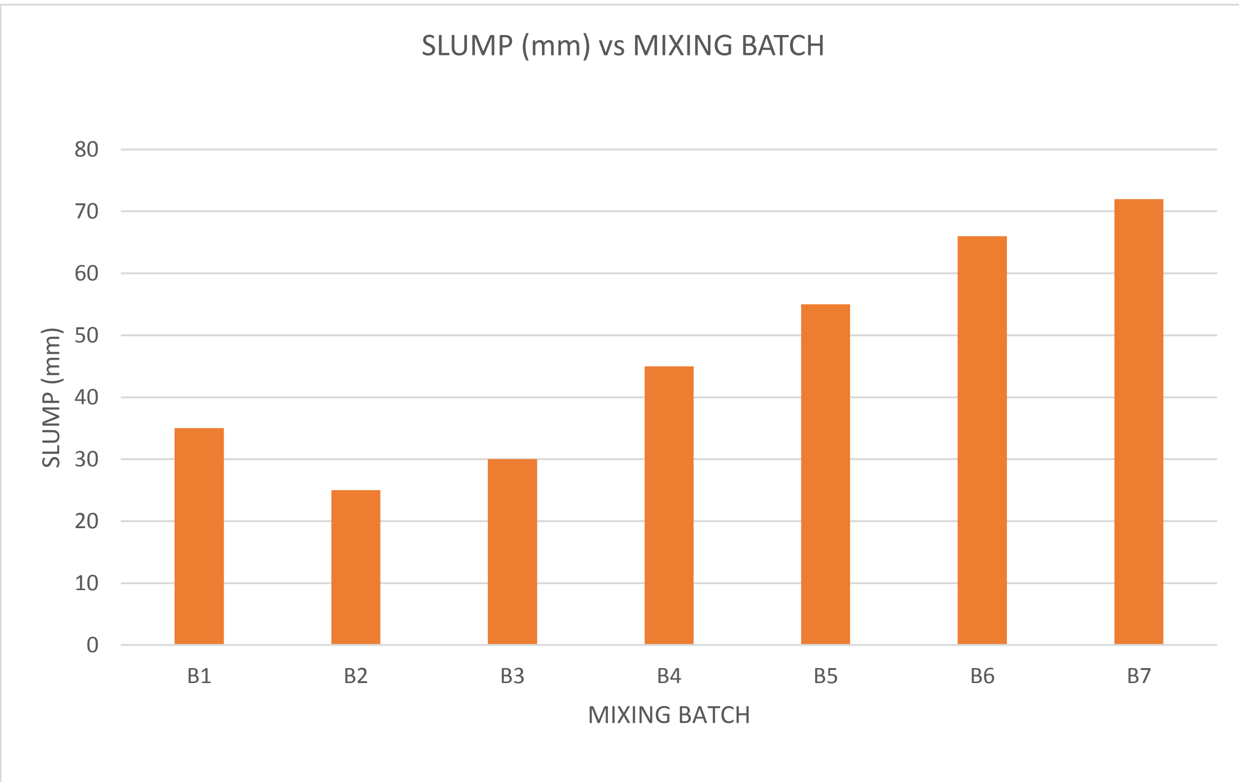

Fig. 5: Slump

The result of slump test above shows that, the introduction of CDA as partial replacement of cement has decrease the workability of concrete while the introduction of WGP has cause the workability to rise up, this proved that the CDA absorbed more water than cement while WGP absorbed less water than cement.

Compressive strength

Table 15: Compressive strength result for cubes cured for 7, 14, 21, and 28 days

Batch Identification	compressive strength (N/mm^2)	compressive strength (N/mm^2)	compressive strength (N/mm^2)	compressive strength (N/mm^2)
	7days	14days	21days	28days
B1	13.79	17.25	19.14	21.41
B2	14.19	17.67	20.00	22.21
B3	14.90	18.06	21.04	24.11
B4	15.05	20.56	22.96	25.62
B5	14.76	18.89	22.02	25.02
B6	16.98	21.20	23.50	26.27
B7	10.23	18.06	21.04	23.93

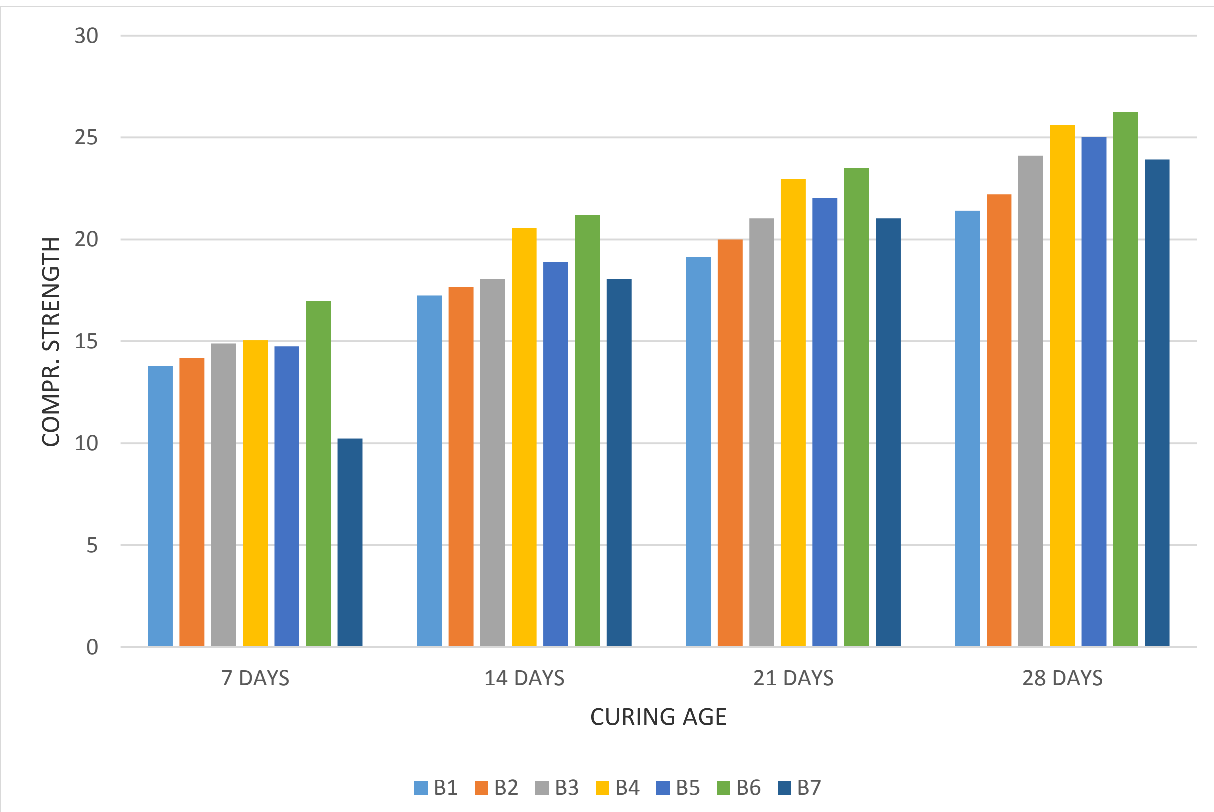

Fig. 6: Compressive strength

From Table 15 and bar chat above, the results shows that the compressive strength of concrete increased to the optimum of 26.27 N/mm^2 which shows that the compressive strength at 28 days is enhance with the partial replacement of cement with waste glass powder at 8 % of the binder and cow dung ash at 10 % replacement of binder for concrete production.

RECOMMENDATION AND CONCLUSION

Recommendations

The use of waste (waste glass and cow dung) as some percentage of binder material in concrete production should be encouraged. The used of waste glass powder at 8% of the binder and cow dung ash at 10% of the binder for production of concrete should be encouraged. Similar studies are recommended for concrete beams and slab sections to ascertain the flexural behavior of concrete made with these materials.

Conclusions

Conclusions drawn here were based on the objectives of this project and observations made during the course of study. The results of this research have been collected, upon which several deductions can be derived following the characteristic behaviours of binder paste, fresh concrete and hardened concrete made from varying proportions of cement to CDA and WGP replacement.

These deductions include:

i. The standard consistency of the binder paste increased from 29% to 31% with 10% replacement of cement with CDA and then with the introduction of WGP at 2%, 4%, 6% replacement the consistency remained at 31%, when it reached 8% replacement the consistency declined to 30% and remained at 30% up to 10% replacement of cement with WGP. So 6% is the optimum content of WGP for standard consistency.

ii. The initial and final setting time of binder paste increased from 49 and 139 mins to 90 and 194 mins respectively with 10% replacement of cement with CDA and then continuously increasing with the introduction of WGP at 2%, 4%, 6% replacement up to 137 and 227 mins, as the replacement reached 8% the initial and final setting time declined to 100 and 185 mins respectively, and further decreased at 10% replacement. So the maximum initial and final setting time is attained at 6% of WGP.

iii. The workability of fresh concrete had been found to be decreased with CDA and then increased sharply to a maximum with the introduction of WGP as cement replacement.

iv. The compressive strength increased with 10% replacement of cement with CDA, and then increased continuously with 2%, 4%, replacement cement with WGP before it slightly declined at 6% and sharply increased to a maximum at 8% before further declination at 10% on progressive substitution of cement with WGP. Thus the optimum content of WGP is 8 % and at this optimum content it was observed that the compressive strength of cow dung ash concrete increased by up to 18.28% of the strength of the control.

v. The compressive strength was much enhanced, the more the cubes are stored for longer curing ages

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