ISSN 2250-3153

Flexural Strength of Concrete beam using Hospital Waste Ash as replacement

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Abstract- This paper is the presentation of flexural strength of concrete beam using hospital waste ash as replacement of cement. The study covered the test of aggregates grading, specific gravity of materials, workability and water absorption as well as the flexural strength test of the composite concrete to determine the suitability of Hospital waste as replacement using constant mix design proportion of 1: 1.64: 2.47: 0.50 in accordance to standard DOE method, with different mixes added based on 0%, 10%, 20%, 30%, and 40% replacement. A total of 75 beams of sizes 450mm × 150mm × 150mm were tested for flexure after the curing period of 3, 7, 28, 60, and 90 days by complete immersion. It shown that the workability of the composite mix decreased with replacement higher than 10%, but density and water absorption increases with replacement level and curing age respectively, while 20% replacement appeared to be the optimum. The study also reveals that,replacement of Hospital Waste Ash under flexural test reduces the flexural strength value as minimum compared to conventional value of concrete. However, it maintains, or slightly reduces the mechanical and durability properties of cement- based materials with cementitious properties that are suitable to be bind together with cement as replacement.

Index Terms- Flexural Strength test, Hospital Waste Ash, Absorption test, Cementitious Properties

1.0 INTRODUCTION

With the advancement of technology and increased application of concrete and mortar; the strength, workability, durability and other characteristics of the ordinary concrete is continually undergoing modifications to make it more suitable for any situation. The growth in infrastructure sectors led to scarcity of cement thus makes it increasing incrementally with time, Example in Nigeria, the cost of cement hits N2600 per bag. In order to combat the scarcity of cement and the increasing cost of concrete under these circumstances; the use of recycled solid wastes, agricultural wastes, and industrial by-products like - fly ash, blast furnace slag, silica fume, rice husk ash, phosphogypsum, Hospital waste ash, volcanic ash, stone dust etc. will sufficed the problems. The use of above mentioned waste products in partial replacement of cement paved a role for; modifying the properties of the concrete, controlling the cost of concrete production, and finally has the advantageous disposal of industrial wastes.

The use of particular waste product will be economically advantageous usually at the places of abundant materials and production. Much of the literature is available on the use of fly ash, blast furnace slag, silica fume, rice husk, etc. However, the literature on the use of hospital waste in construction industrybegins to develop. This paper tries to focus on the use of hospital waste in partial replacement of cement in concrete.

According to Becher and Lichtnecker (2002), medical waste presents a high risk to doctors, technicians, sweepers, hospital visitors and patients due to arbitrary management. It poses threats to environmental health and requires specific treatment and management prior to its final disposal [1] (Hassan *et al*., 2008).

It has equally received very little attention in Nigeria in contrast to the management of other types of solid waste as hospital waste management was in a deplorable state with less or no provision for the health-care waste disposal. By the nature of its composition, hospital waste is a breeding ground for all sorts of diseases and infections if not properly handled, managed and controlled. In Nigeria, as close to the end of the third millennium, it was observed that there were weak policies on hospital waste management in Nigeria, and that is why it is not uncommon to find various components of hospital waste like used syringes, discarded blood vials, needles, empty description bottles etc. improperly disposed and left untreated [2] (Coker *et al*., 1998). Hence, this study aims to determine the flexural strength of concrete using hospital waste ash as replacement.

2.0 BACKGROUND OF THE RESEARCH

Elinwa (2002), reported that 10% replacement of cement with saw dust ash (SDA) showed good performance giving the desired workability and strength [3].

Siva and Kumar (2010), reported that an industrial waste like phosphogypsum impairs the strength development of calcined products and hence it can be used in construction industry for preparation of concrete replacing some quantity of cement, which is a valuable ingredient of concrete, to achieve economy. With 10% replacement of cement with phosphogypsum the flexural strength not only decreased significantly with higher replacement of cement with phosphogypsum but with increase in water-binder ratio also. The width and number of cracks increased with the increase in replacement of phosphogypsum above 10% [4].

Vegas and Urette (2006), incorporation up to 20% calcined paper sludge into cement paste modifies initial setting time by accelerating the process just to 60 minutes. Workability is reduced when using calcined paper sludge. The partial replacement of cement by calcined paper sludge enhances flexural strengths slightly after 7 days of curing.

According to the results of flexural strength test, all the replacement degrees of RHA researched, achieve similar results. Then, it may be realized that there is no interference of adding RHA in the flexural strength. All the samples studied have similar results in elasticity module. A decreasing in the module is realized when the levels of RHA are increasing [5].

Khater (2011), Flexural strength of all the studied mixes increases with hydration age and decreases with burned dust giving-more than 20 kg/cm^2 enough for safe handling, after one day of hydration except for mix that has full replacement by dust. After one day of water curing, all mixes give flexural strength exceeds that required for the concrete bricks used in the non-load bearing walls (25 kg/cm^2), according to the Egyptian Standard specifications 1292 (1992), except the specimens of the mix of 100 wt. % burned cement dust replacement that reaches the last mentioned value after 3 days. Beyond 3days mixes having up to 60 wt. % BD give a flexural strength higher than that required for the concrete bricks used in the load bearing walls (70 kg/cm^2). According to the same Egyptian standard specifications, the specimens of all mixes at all water curing periods have a moderate bulk density (1.40 to 2.00 g/cm^2). The results of this study show that the mix of waste concrete, grog, hydrated lime and burned cement dust can be used instead of the cement constituent in mortars, and in concrete brick-making. In spite of the decrease of flexural strength values (main property of building materials) with the replacement of hydrated lime by burned dust, yet these values reach the flexural strength required for the brick used for the load bearing walls (70 kg/cm^2) after 1, 3 or 28 days of hydration in addition to the benefit of saving a raw material (hydrated lime) that used in many industries using an environmental pollutant waste dust instead. Generally, it could be said that direct replacement (mixing) of burned cement dust with demolished wastes is more effective than the recycling of dust with cement raw materials, which forms unfavoured clinker phase during the firing in cement kilns that attributed to the effect of high dust alkalinity on the nature of clinker phases [6].

Eduardo (2010), reported that sugar cane bagasse ash (SCBA) maintains, or even improves, the mechanical and durability properties of cement-based materials such as mortars and concretes and has cementitious properties indicating that it can be used together with cement [7].

Joo Hwa (2003), reported that mixes containing the ash have a slightly higher workability than the control (0% ash) mix. In the mix containing 10% ash, strengths comparable with or higher than that of the control mix were obtained, whereas the 20% and 30% ash mixes had strengths about 40%–50% lower [8].

Kula (2002), reported that flexural strength of all specimens containing 1 wt. % of tincal ore waste was higher than that of the control at the 28th day of curing. At 90 days, the contribution to strength by Bottom ash (BA) + Tincal ore waste (TW) and Fly ash (FA) was higher than in the concrete-prepared equivalent TW beyond 3 wt. % of Portland cement (PC) replacement. With the replacement of 3–5 wt. % of PC by TW, the flexural strength of the concrete decreased compared to control concrete. However, the values obtained are within the limit of Turkish Standards (TS). Adding BA or FA with TW improved the performance relative to TW replacement only. Increasing replacement of TW gives rise to a higher setting time. As a result, TW, BA, and FA samples may be used as cementitious materials [9].

Canpolat (2004), reported that replacement materials have some effects on the mechanical properties of the cement. The inclusion of zeolite up to the level of 15% resulted in an increase in flexural strength at early ages, but resulted in a decrease in flexural strength when used in combination with fly ash. Also, setting time was decreased when zeolite was substituted. The results obtained were compared with Turkish Standards (TS), and it was found that they are above the minimum requirements [10].

3.0 MATERIALS AND EXPERIMENTATION

3.1 Materials

3.1.1 Hospital waste: The sample of the hospital waste ash was obtained from a small scale incinerator at Abubakar Tafawa Balewa University Teaching Hospital Bauchi. It was then grinded and sieved through 150 µm sieve and finally incorporated into the concrete as cement replacement. Below table shows the chemical composition of the Hospital waste ash.

Table 3.1: Chemical Compositionof Hospital waste ash

Chemical Constituent	Percentage by weight (%)
SiO_2	20.60
P_2O_5	0.95
$S0_3$	1.50
Cl	2.38
K_2O	9.78
TiO_2	1.20
CaO	47.43
$V_2 0_5$	0.04
CrO_5	0.04

MnO	0.22
Fe_2O_3	8.06
NiO	0.01
CuO	0.08
ZnO	0.19
Br	0.02
SrO	0.41

3.1.2 Cement: Ashaka brand of ordinary Portland cement was used throughout the course of this project, and conform to BS 1881.

- Physical properties

Cement is a fine grey powder. It is mixed with water and materials such as sand, gravel and crushed stones to make concrete. The cement and water forms paste that binds the other materials together.

Table 3.1.2: Physical Properties of Cement

Specific Gravity	3.15
Lose Bulk Density (Kg/m^3)	3150
Loss on Ignition (%)	1.0
Specific Surface (m^2/g)	2.30
Soundness (mm)	9.25

- Chemical Properties

Portland cement is composed of four major oxides: Lime, silica, alumina and iron. It also contains small amount of magnesia, alkalis and sulfuric anhydride as shown in Table 3.1.2 below:

Table 3.1.2: Chemical Composition of Cement

Oxide	Common Name	Percentage by Weight (%)
CaO	Lime	60 - 67
SiO_2	Silica	17 - 25
Al_2O_3	Alumina	3 – 8.0
Fe_2O_3	Iron	0.5 -6
MgO	Magnesia	0.1 – 4.0
Na_2O and K_2O	Alkalis	0.2 – 1.3
SO_3	Sulfuric anhydride	1 – 3.0

3.1.3Fine aggregate: The sand used in this experimental work was river sand and conformed to the requirement of BS 882.

3.1.4Coarse aggregate: Coarse aggregate for this research was obtained from quarry in Bauchi state and it conformed to the requirement of BS 882.

3.1.5Water: Ordinary drinking water from tap was used in this research work.

3.2 Experimentation

In this research work, the various tests carried out include:

3.2.1 Concrete mix design:

In this work a mix proportion of 1:1.64: 2.47:0.50 was used throughout, the detailed mix design has been presented in appendix Table 3.2 below shows the percentage of the constituent materials;

Table 3.2.0: Mix Proportion

Mix No. (%)	Cement (Kg)	Fine aggregate (Kg)	Coarse aggregate (Kg)	Hospital waste ash (Kg)	Water content (Kg)
M-0	51.03	84.08	126.12	_	25.52
M-10	45.93	84.08	126.12	5.10	25.52
M-20	40.82	84.08	126.12	10.21	25.52
M-30	35.72	84.08	126.12	15.31	25.52
M-40	30.62	84.08	126.12	20.41	25.52

3.2.2 Casting of Beams:

The fresh concrete was placed in 450 mm×150 mm ×150 mm mould and compacted. A total of 75 beams were casted. The casted beams were then completely immersed in water at room temperature after 24 hours.

3.3 Characterization of Materials

3.3 Sieve analysis:

The grading was carried out in accordance with BS 812 part 1 (1975).The sand was air dried for 24 hours and 1000g of the sand were weighed and passed through the following set of sieves 10mm, 5.0mm, 2.36mm, 1.18mm, 600μmm, 300μmm, 150μmm,

$75\mu mm$, and pan. The setup was shaken manually; the particles retained on each sieve were weighed and recorded. The result were expressed as a percentage by weight of materials passing each sieve as shown in Table 4.1 and figure 4.1 chapter four.

3.4 Test carried out on Fresh Concrete

3.4.1 Soundness Test:

The cement paste was prepared by gauging cement with 0.78 times water required to give a paste of standard consistency. The gauging time was 4 minutes. The inner surface of the mould was oiled. The mould was then placed on a glass plate and filled with cement paste, taking care to keep the edges of the mould gently together. The mould was covered with another piece of glass plate and a small weight was placed on this covering glass plate and immediately submerged the whole assembly in water at a temperature of 27°C and keeps it for

24 hours. The assembly was then removed from water after 24 hrs. The distance between the indicator points was measured and recorded as (D1). The mould was submerged again in water to boiling in 25 to 30 minutes and was kept boiling for three hours. The mould was removed from the water, allowed to cool and the distance between the indicator points was measured and recorded as (D2). Two samples were tested and average of the results was reported and shown in Table 4.4 and detailed in appendix ii.

3.4.2 Consistency Test:

The test was conducted in accordance with BS 196 part 3, (1996) which is similar to IS: 4031, Part 4 (1988) 400g of cement was weighed and mixed with a weighed quantity of water. The time of gauging was about 5 minutes. The Vicat mould was filled with the cement paste and was leveled with a trowel. The plunger was lowered gently to tilled it touched the cement surface and was released, allowing it to sink into the paste. The reading on the gauge was noted. The above procedure was repeated taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7mm.

3.4.3 Initial and Final Setting Time

- Initial Setting Time:

The test was conducted according to Indian standard IS: 4031, Part 5 (1988).Cement paste of 400g was prepared by gauging the cement with 0.85 times the water required to give a paste of standard consistency. Stop-watch was started the moment water was added to the cement. Vicat mould was filled completely with the cement paste gauged as above; the mould resting on a non-porous plate and the surface was smooth off, making it level with the top of the mould. The cement block thus prepared in the mould is the test block. The test block was then placed under the rod bearing the needle. The needle was lowered gently in order to make contact with the surface of the cement paste and was then release quickly, allowing it to penetrate the test block. This procedure was repeated until the needle fails to pierce the test block to a point 5.0 ± 0.5mm measured from the bottom of the mould. The time period elapsing between the time, water was added to the cement and the time, the needle fails to pierced the test block by 5.0 ± 0.5mm measured from the bottom of the mould, was recorded as the initial setting time.

- Final Setting Time:

The initial setting time needle was replace by the one with an annular attachment. The cement was considered as finally set when, the needle was released gently to the surface of the test block, and the needle makes an impression therein, while the attachment fails to do so. The period elapsing between the time, water is added to the cement and the time, the needle makes an impression on the surface of the test block, while the attachment fails to do so, was recorded as the final setting time. The result was reported and shown in Table 4.3 and detailed in appendix ii.

3.4.4 Workability (slump test)

The slump test was conducted in accordance with BS 1881: part 102 (1983), a truncated cone of 300mm height with 200mm and 100mm bottom and top diameter respectively was used for this test. The cone was cleaned with damp cloth, left to dry and lightly lubricated. It was then placed on a metal plate and held in place. It was filled in three layers each being compacted by at least 15 short strokes of a tamper to ensure uniform filling of the mould. The outer surface was wiped and cleaned. After 15 seconds, the cone was raised vertically at a constant rate; the reduction in height of the specimen was measured and recorded as the slump. Test results were presented in Table 4.2

3.5.0 Test Conducted on Hardened Concrete

3.5.1 Water absorption test:

The test was conducted in accordance with BS 1881 part 122 (1983). The concrete beams were removed from the curing tank; they were then weighed under saturated surface dry condition and after air dried for 24 hours. Finally the percentage difference in weight between the air dried and weight (SSD) is the water absorbed.

$$\text{Water absorption} = \text{weight of water (kg)}/\text{weight of sample} \times 100\%$$

The summary of result of this test was presented in chapter four and detailed in Appendix 111.

3.5.2 Pozzolanic activity index test:

The test was carried out in accordance with EN 196 part 5 (1996). The pozzolanic activity index is a number based on the flexural strength of sample beams such that:

$$\text{Pozzolanic activity index with Portland cement} = A/B \times 100$$

Where, A is the average compressive strength of test mix beams containing pozzolana (N / mm^2), and B is the average compressive strength of pozzolana free test beam mix (N/ mm^2).

3.5.3Flexural Strength Testing:
At the required ages (3, 7, 28, 60 and 90 days), three beams were removed from the curing tank and tested for flexure in accordance with the method prescribed in BS 1881 Part 188,1983.The results were reported individually. The specimen was placed and ensured that it is symmetrical on the supporting blocks as specified. The loading block adjusted to fit the test specimen using the knob at the side of the machine and then tightened. The pointer was adjusted to zero and the operation started by moving the handle to and fro until the beam failed. The maximum ultimate load at failure was recorded.

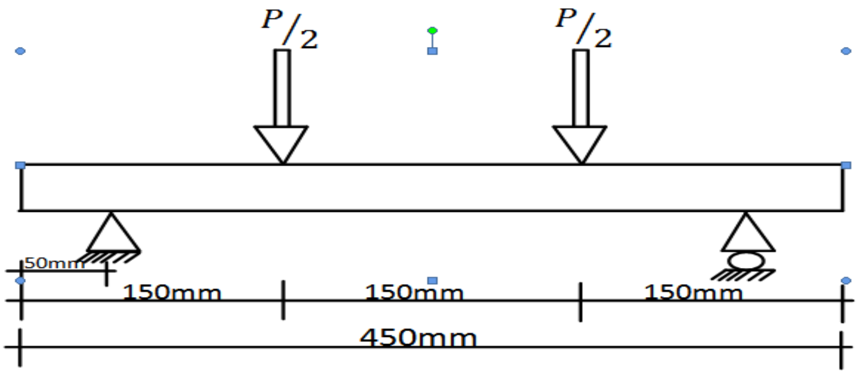

Figure 1: Beam Diagram

The modulus of rapture (MOR) was computed on the basis of ordinary elastic theory, using the following formula: if the fracture occurs within the third middle of the beam (i.e. when “a” is greater than 133mm, which is 1/3 of the beam size).
Flexural strength:

$$Fb\ (N/mm^2) = PL/bd^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

But if “a” is less than 133mm (i.e. fracture occurs outside the load point). The equation used is:
Flexural strength:

$$F_b\ (N/mm^2) = 3pa/bd^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Where; P is the failure load (N)
a = Distance of line of rapture from the nearest support (mm)
L = Beam span (mm)
b = Width of the beam (mm)
d = Depth of the beam (mm)
Both equation (i) and (ii) above was used base on the distance of line of rapture from the nearest support.

4 RESULTS AND DISCUSSION

4.1 SIEVE ANALYSIS:

The result of sieve analysis performed on the aggregate presented in table 4.1 shows that it is well graded as shown in figure 4.1 and was found to be in Zone 2 according to BS 882 part 2 (1973) grading limits of fine aggregate.

Table 4.1.0: Sieve Analysis Result of Coarse Aggregate

Sieve size	Mass retained	Mass passing	Cumulative mass retained	% Retained	% Passing
10	0.00	1000	0	0.0	100.00
5	19.02	980.98	19.02	1.90	98.10
2.36	143.78	837.2	162.8	14.38	83.72
1.18	196.64	640.5	359.44	19.66	64.06
0.6	200.06	440.5	559.5	20.91	44.05
0.3	232.05	208.45	791.55	23.21	20.84
0.15	175.96	32.49	967.51	17.59	3.25
0.075	19.45	13.09	986.96	1.95	1.30
pan	5.30	7.74	992.26	0.53	0.77
Total	1000				

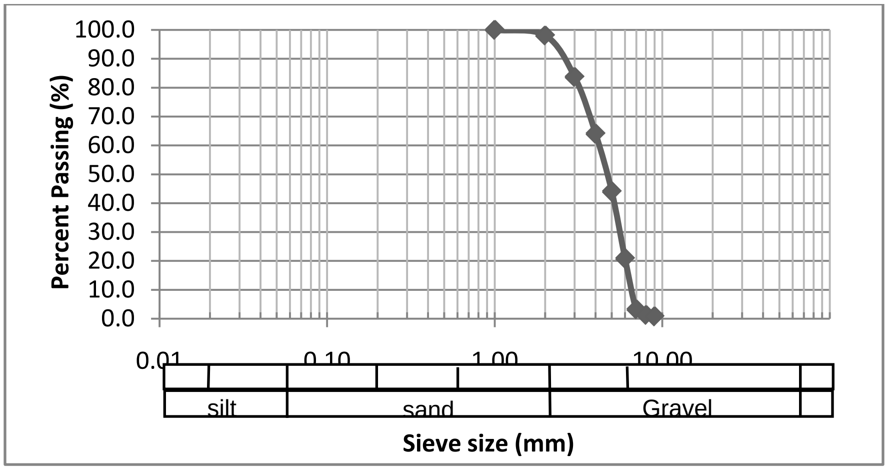

Figure 2.0: Grading curve for Coarse Aggregate

Table 4.1.1: Result of sieve Analysis of Fine Aggregate.

Seive size (mm)	6.3	5.0	4.76	3.35	2.4	1.2	0.6	0.3	0.15	Pan
Percentage Passing (%)	100	99	98	88	60	30.5	14	6.1	0.9	0.00

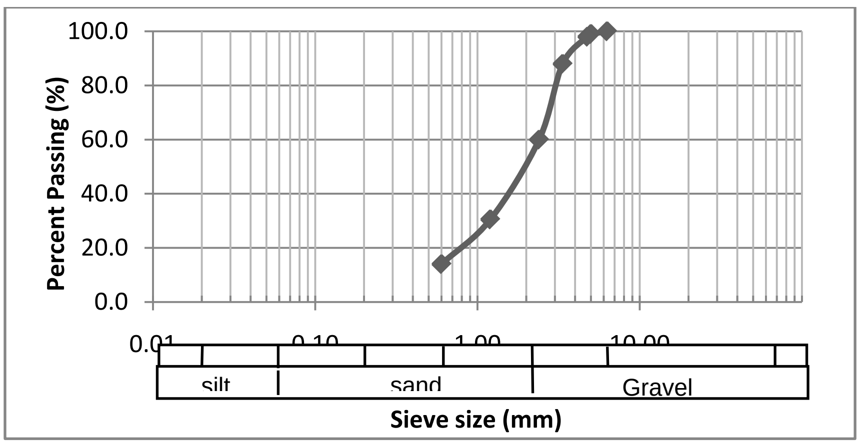

Figure 3.0: Grading curve for Fine Aggregate

4.2 Workability (Slump test):

Incorporation of Hospital waste ash has greater effect on the workability of the concrete. Table 4.2 showed the results, the slump was greater for 10% replacement, suddenly these values reduced as the replacement level increases. As shown in figure 4.2 below and presented in Figure 4.0

Table 4.2: Workability (slump)

Mix NO	**Slump (mm)**
M-0	21
M-10	25
M-20	20
M-30	19
M-40	15

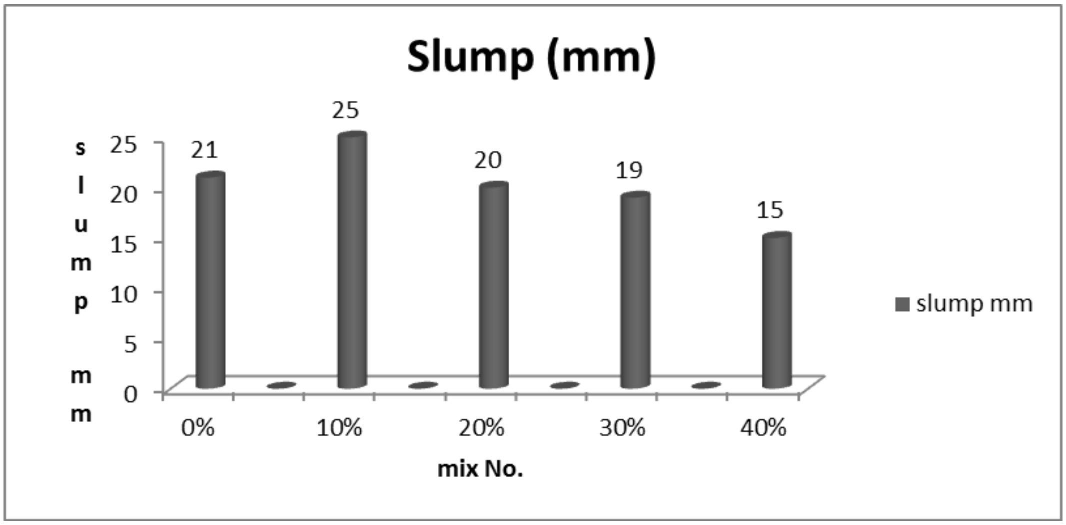

Figure 4.0: Slump (mm) against Mix No (%)

4.3 Setting Time: Mixes containing the ash has higher setting time as compared to the control mix as shown in Table 4.3 below .

Table 4.3: Setting Time and Normal consistency Result

Mix No	Initial Setting Time(minutes)	Final Setting Time (minutes)	Normal Consistency (%)
M-0	45	496	29
M-10	185	876	34
M-20	300	985	36
M-30	490	1075	39
M-40	670	1100	41

Table 4.4: Soundness of Cement Result

Mix No (%)	Average (mm)
M-0	9.62
M-10	12.25
M-20	11.08
M-30	11.25
M-40	13.33

4.5 Water absorption: Table 4.5 has shown the summary of results obtained, water absorption increased with increased in curing age for both the control and other replacement levels. Figure 5.0 presented these results.

Table 4.5: Summary of Water absorption

AVERAGE WATER ABSORPTION (%)					
Mix No	**3 days**	**7 days**	**28 days**	**60 days**	**90 days**
M-0	1.98	2.10	6.61	11.04	11.98
M-10	1.98	2.10	6.61	10.80	12.00
M-20	1.99	3.92	7.28	10.81	11.92
M-30	3.00	4.62	6.72	11.25	11.69
M-40	2.69	4.30	8.33	10.81	12.24

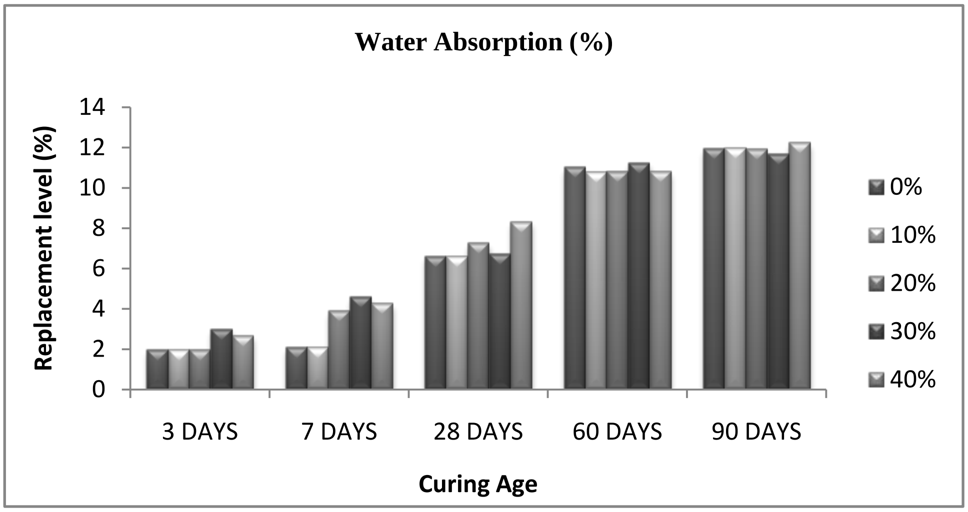

Figure 5.0: Water Absorption

4.6 Density of Concrete: The concrete mix was designed for a density of 2360 kg/m^3 but the test result shows higher average values for the modified concrete as in Table 4.6, the control has an average density of 2553 Kg/m^3 which is above target, while 10%, 20%, 30% and 40% replacement give an average of 2609 Kg/m^3, 2649Kg/m^3, 2643 Kg/m^3, 2585 Kg/m^3 respectively, but the percentage difference is minimal, Figure 4.4 below shows a bar chart of the result averages.

Table 4.6: Summary of Concrete Density

	MIX NO				
Age (days)	**M-0**	**M-10**	**M-20**	**M-30**	**M-40**
3	2548	2548	2535	2601	2522
7	2550	2550	2627	2647	2591
28	2629	2629	2742	2719	2589
60	2519	2785	2785	2741	2737
90	2522	2537	2558	2509	2489

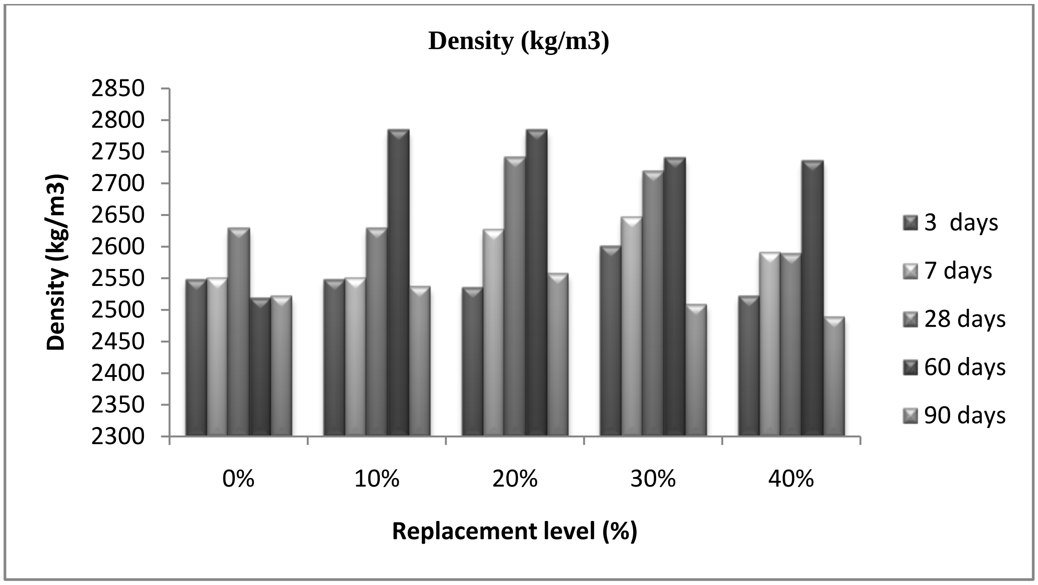

Figure 6.0: Average density against curing age

4.7 Flexural Strength Test:

The results of the test were shown in Table 4.7, which showed that the addition of Hospital waste ash led to a decrease in flexural strength (modulus of rapture), a bar chart Figure 7.0 compared the percentage decreased in modulus of rapture against age. For the control mix the flexural strength increased with curing age, while for 10% and 20% replacement maximum value of flexural strength was obtained at 7 days, then it suddenly declines with curing age, it declines at 28 days and increase at both 60 and 90 days. For 30% and 40% replacement, maximum value of flexural strength was obtained at 28 days; it then declined with curing age.

Table 4.7: Summary of Flexural Strength Test

	Average Modulus of Rapture (N/mm^2)				
Mix No	**3 (days)**	**7 (days)**	**28 (days)**	**60 (days)**	**90 (days)**
M-0	3.32	3.39	3.83	4.92	4.80
M-10	3.21	3.95	3.70	3.40	3.12
M-20	2.12	4.12	3.50	4.02	4.01
M-30	2.22	3.16	3.64	3.51	3.25
M-40	1.17	1.97	3.50	3.14	3.10

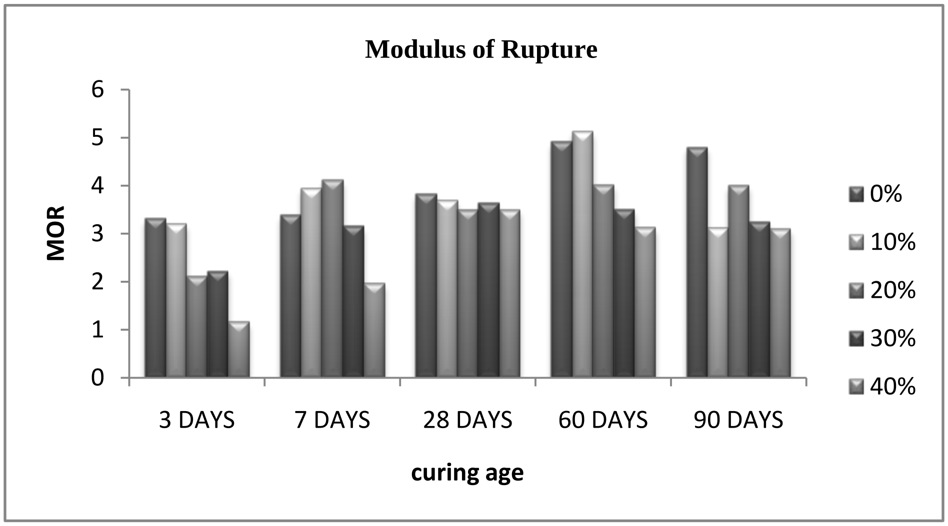

Figure 7.0: Comparison of percentage decrease in MOR for various Mix No (%)

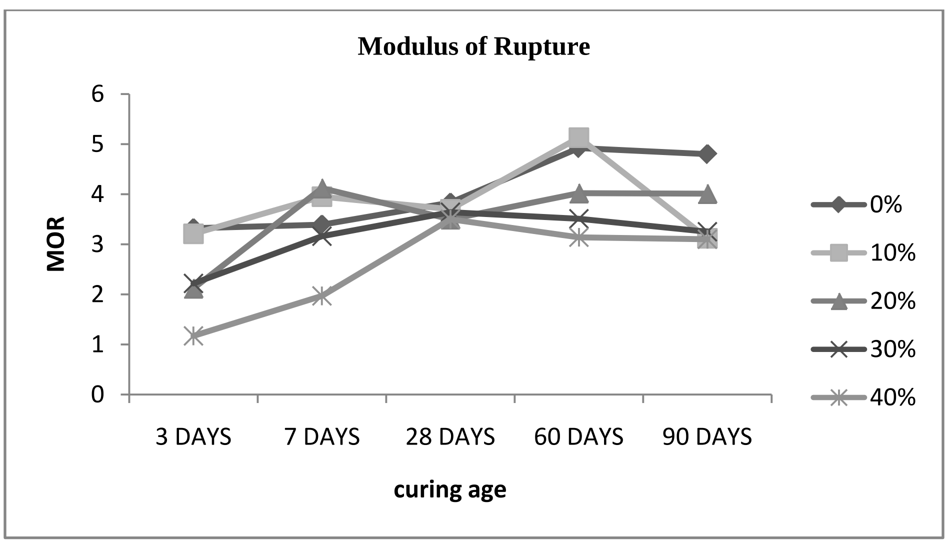

Fig 8.0: Average Flexural strength against curing age

4.6 Pozzolanic Activity Index Test (PAI):

The Pozzolanic activity index (PAI) of Hospital Waste Ash with OPC refers to ratio of the compressive strength at 28 days of the test of 10% of pozzolana specimen to that of control specimen expressed in percntage.

PAI = Compressive strength of 10% at 28 Days of test specimen / Compressive **strength of control specimen at 28 days × 100%**

Table 4.8 Pozzalanic Activity Index Test

Mix No	Mean Strength (N/mm^2)	Mean PAI (%)
M-0	25.02	
M-10	21.51	85.97

4.0 CONCLUSION

Based on the results obtained from various tests undertaken, it shown that; Hospital Waste Ash used for the research has about 85.97% of PAI which makes it suitable to be used as a pozzolana since this value exceeds the 70% specified by ASTM. Also, the slight decrease in the modulus of rapture due to increase in replacement clearly indicated that Hospital Waste Ash is a durable construction material and it can be utilized in concrete production.

APPENDIX

S/No.	Curing age (days)	Beam size (mm)	Span between supports, L(mm)	Factor bd^2 (mm^3) ×10^6	Distance of line of Rapture, a (mm)	Failure load (KN)	Modulus of Rapture (N/mm^2)	
HOSPITAL WASTE (M-20) 20% REPLACEMENT								
1	3 days	150×150×450	350	3.375	130	19.00	2.19	2.12
2					150	20.00	2.07	
3					140	20.20	2.09	
4	7 days	150×150×450	350	3.375	160	38.10	3.95	4.12
5					165	41.20	4.27	
6					160	40.00	4.15	
7	28 days	150×150×450	350	3.375	155	31.80	3.30	3.50
8					165	34.30	3.56	
9					145	33.50	3.50	
10	60 days	150×150×450	350	3.375	145	44.20	4.58	4.02
11					170	33.80	3.51	
12					176	38.40	3.98	
13	90 days	150×150×450	350	3.375	150	37.20	3.86	4.01
14					162	43.00	4.46	
15					148	36.00	3.73	

ACKNOWLEDGMENT

The Authors wish to acknowledge Prof. A. U Elinwa for his guidance, and all the Civil Engineering Staffs for their inputs and suggestions toward the completion of this research.

REFERENCES

[1] Hassan, M.M., S.A. Ahmed, K.A. Rahman and T.K. Biswas. (2008), "*Pattern ofmedical waste management*" Existing scenario in Dhaka City, Bangladesh. J. BMC Public Health, 8(36): 1-19.
[2] Coker, A.O., A.Y. Sangodoyin and O.O. Ogunlowo. (1998), "*Managing HospitalWastes in Nigeria*." Proceedings of the 24th Annual Conference of Water Engineering and Development Centre (WEDC), Loughborough University, U.K., pp: 70-72.
[3] Elinwa (2002), "*Ash from timber waste as cement replacement material*" cement and concrete composites. Volume 24, issue 2nd, April 2002.Page 219-222
[4] Siva and Kumar (2010), "*A study strength characteristics of phosphogypsumconcrete*" Asian journal of civil engineering. vol., 11, No.4 page 411-420
[5] Vegas and Urette (2006), "*Rheology and conduction calorimetric of cementmodified with calcined paper sludge*" cement and concrete research, vol. 37, issue 21 Feb. 2007 page 184-190.
[6] Khater (2011), "*Utilization of demolished concrete, grog, hydrated lime andcement kiln dust in building materials*" Housing and building Natural research centre Cairo Egypt.
[7] Eduardo (2010), "*Cement replacement by sugar cane bagasse ash, carbon dioxideemissions reduction and potential for carboncredit*" Journal of environmental management. Volume 91 issue 9th, September 2010 page 1864-1871.
[8] Joo Hwa (2003), "*Used of ash derived from refused incineration as partialreplacement of cement*" cement and concrete composite vol.13 issue 3, Sept., 1991 page171-175.
[9] Kula (2002), "*An investigation on the use of tincal ore waste, fly ash and coalbottom ash as Portland cement replacement*" Cement and concrete research.vol.34.issue 2nd, Feb., 2002, pg 227-232.
[10] Canpolat (2004), "*Use of zeolite, coal bottom ash and fly ash as replacementmaterials in cement production*" Cement and concrete research.vol.34, issue 5, May 2004, pg 731-735.