COMPRESSIVE STRENGTH OF LIGHTWEIGHT CONCRETE AND BENEFIT OF PARTIALLY REPLACING CEMENT BY ANIMAL BONE ASH (ABA)

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ABSTRACT: This experimental investigation has been performed in order to evaluate the strength of lightweight concrete, in which cement was replaced from 0% to 20% with animal bone ash. The test has been conducted on hardened concrete for M_{20} concrete using IS method. The lightweight concrete is obtained by replacing coarse aggregate with pumice (i.e. solidified magma). Lightweight concrete has many advantages compared to the conventional concrete especially in the multistoried building due to its low density of about 300 to 1850 Kg/m^3 compared to conventional concrete weight with a density of about 2200 to 2600 Kg/m^3. In this research, coarse aggregate has been replaced 100% with the pumice to manufacture the lightweight concrete. On the other hand, cement has been replaced with animal bone ash, a cleaned and dried animal bone has been burned in the clinker to obtain its powder, then the powder has been used partially as a cement replacement in series of 0%, 5%, 10%, 15%, to 20% at different cubes and the cubes were cured for 28 day. Compressive strengths were determined at 7, 14 and 28 day of curing and at the end it has been found that, the compressive strength reduces from 0% to 10% and there was a slight increase from 10% to 15% followed by a rapid decrease in strength from 15% to 20%, and the concrete mix containing not more than 5% of animal bone ash showed a little reduction in the final strength (less than 10%), they can still be used for major construction work. The 10% and 15% replacement can be used for lightweight concrete for blinding and German floor.

Keywords: Animal Bone Ash, Compressive strength, Lightweight concrete, Pumice.

INTRODUCTION

Concrete has been the most familia building material for many years. And it is expected to remain so in the coming decades. Must of the developed world has infrastructures built with various forms of concrete. Mass concrete dams, reinforced concrete buildings, pre-stressed concrete structures, and precast concrete components are some typical examples. It is anticipated that the rest of the developing world will use these forms of construction in their future development of infrastructures. In pre-historic times, some form of concrete using lime-based binder may have been used [Stanley, 1980], but modern concrete using Portland cement, which sets underwater, dates back to the mid-eighteenth century and more importantly, with the patent by Joseph Aspdin in 1824. Traditionally, concrete is a composite material consisting of the dispersed phase of aggregates (ranging from its maximum size coarse aggregates down to the fine sand particles) embedded in the matrix of cement paste. This Portland cement concrete has four constituents of Portland cement, water, stone and sand. These essential components remain in current concrete, but other constituents are now often added to modify its fresh and hardened properties. This has broadened the scope in the design and construction of concrete structures. It has also introduced factors that designers should recognize in order to realize the desired performance in terms of structural adequacy, constructability, and required service life. These are translated into strength, workability and durability in relation to properties of concrete. In addition, there is a need to satisfy these provisions at the most cost-effective price in practice. So due to that, pumice will fully replace coarse aggregate, and animal bone ash will partially replace cement.

MATERIALS USED

The materials used for this experiment:

1. Fine aggregate (sand)
2. Portland cement
3. Water
4. Animal bone ash
5. pumice

Fine Aggregate: the fine aggregate (sharp sand) used has been obtained from Wudil River which has moisture content of 1.12% and from sieve analysis it has been found that the sand has fineness modulus of 5.4 which implies that the sand has some identifiable portion of coarse materials, and the bulk density for compacted sand is 1555 kg/m^3 while for uncompacted sand is 1422 kg/m^3, the sand has an average specific gravity of 2.65 and a void ratio of 0.46.

Coarse Aggregate: (normal aggregate) Crushed aggregates particles passing through 20mm and retained on 10mm has been obtained from the quarry site**.** The coarse aggregate used has a moisture content of 0.62, the bulk density of compacted gravel 1668 k/m^3 and for uncompacted gravel 1503kg/m^3, the average specific gravity of 2.6 and a void ratio of 0.42.

Portland cement: Cement used throughout the project is "Dangote Portland Cement" which is a type I ordinary Portland cement (i.e. a general-purpose Portland cement suitable for most uses) which conformed to BS 12 (1996) requirement. The cement will be sourced from Wudil market, Kano State, Nigeria.

Water: The water for the mixing was sourced from a borehole within Wudil town which conformed to BS 3148 (1980) requirements.

Animal Bone Ash: animal bone (cow bone) ash has been obtained from Kano abattoir and burned at KUST Wudil. The bones used were naturally dried, that is, dried as much as possible to reduce the moisture content to the nearest minimum by oven drying it. The bones were burnt in a controlled fire so as not to allow contamination and loss of ash using kerosene as fuel. They were completely burnt to ashes and left to cool. The bones were then grounded into powder form using a grinder. The Bone is a highly specialized form of connecting tissue, and it is distinguished from another form of connecting tissue by the fact that it is extremely hard, owing to the deposition within a soft organic composed of calcium minerals substance composed mainly by calcium, phosphate and carbonate (Vaughan, 1975).

Pumice: The coarse aggregate is crushed pumice of 20mm maximum aggregate sizes obtained from kurmi market, which has a density of 1500kg/m^3 passing through 20mm and retained on 10mm. Generally, it has not a crystalline structure, and SiO_2 and Al_2O_3 constitute major contents of the pumice.

METHODS AND METHODOLOGY

1. Nine (9) grade M_{20} Conventional concrete cubes measuring (150 x150 x150) mm have been cast (as a control)
2. Nine (9) lightweight Concrete cubes measuring (150 x150 x150) mm have been cast for each 0%, 5%, 10%, 15%, and 20% replacement of cement with animal bone ash and 100% replacement of coarse aggregate with pumice.

Compaction Factor: The following table (Table 1) gives the values obtained from the compaction factor test carried out on the different samples under consideration

Table 1: Compaction factor for 0%, 5%, 10%, 15%, and 20% replacement of cement

Samples	Un-Compacted Weight (kg)	Compacted weight (kg)	Compaction factor
0%	12.98	14.30	0.91
5%	14.23	15.28	0.93
10%	14.02	15.19	0.92
15%	13.14	14.90	0.88
20%	13.21	14.88	0.89

Table 2: Water absorption for gravel (20mm)

Trial Number	1	2	3
Weight of can (g)	22.7	27.9	19.9
Weight of can + wet sample (g)	91.8	65.8	63.9
Weight of can + dry sample (g)	91.3	65.5	63.6
Weight of dry sample (g)	68.6	37.6	44.0
Increase in mass (g)	0.5	0.3	0.3
Absorption	0.73	0.80	0.68
Average	0.74		

The average value of water absorption from Table 2 is 0.74.

Table 3: Slump Height values for the different concrete replacement

S/N	Percentage Replacement	Slump Height
1	0%	16mm
2	5%	18mm
3	10%	18mm
4	15%	23mm
5	20%	30mm

The slump type associated with all the tests performed for the various percentage replacements is the Shear Slump. Slump is affected by the water/cement ratio and based on these values; the concrete is workable as there was no total collapse of the slump.

Compressive Strength Test: The compressive strength of the all the types of concrete has been determined at 7, 14 and 28 days curing using crushing test i.e.

1. Crushing three conventional concrete cubes each at 7, 14, and 28 days and calculating their average, which serves as a control.
2. Crushing three lightweight concrete (100% pumice) with each 0%, 5%,10%,15%, and 20% replacement of cement with animal bone ash at 7,14 and 28 days curing.
3. Comparing the compressive strengths of each cube (i.e. a total of 45 cubes) after the complete research and determining the strongest concrete among.

RESULT

The details are as shown below:

A = 0% replacement of cement in light weight concrete

B = 5% replacement of cement in light weight concrete

C = 10% replacement of cement in light weight concrete

D = 15% replacement of cement in light weight concrete

E = 20% replacement of cement in light weight concrete

Volume of cube = $(0.15 \times 0.15 \times 0.15)\ m^3 = 3.375 \times 10^{-3}\ m^3$

Area of cube = $(150 \times 150)\ mm^2 = 22500\ mm^2 = 2.25 \times 10^{-2}\ m^2$

Table 4: Compressive strength result for cubes cured for 7, 14 and 28 days of curing.

Sample identification	Weight of cube (kg)	Density of cube (kg/m^3)	Failure load (kN)	Average Compressive strength (N/mm^2)
A (7 days)	8.85	2262.20	560	15.31
A (14 days)	8.92	2643.00	600	19.67
A (28 days)	8.56	2536.30	520	24.89
B (7 days)	8.68	2571.85	497	15.49
B (14 days)	8.82	2613.33	494	20.49
B (28 days)	8.36	2477.04	550	22.83
C (7 days)	8.49	2515.56	316	15.03
C (14 days)	8.48	2512.60	328	18.70
C (28 days)	8.39	2486.00	328	14.40
D (7 days)	8.40	2488.89	374	14.90
D (14 days)	8.07	2391.11	372	17.57
D (28 days)	8.26	2447.41	389	16.81
E (7 days)	8.97	2657.78	240	13.47
E (14 days)	8.67	2568.89	268	15.80
E (28 days)	8.64	2560.00	200	10.49

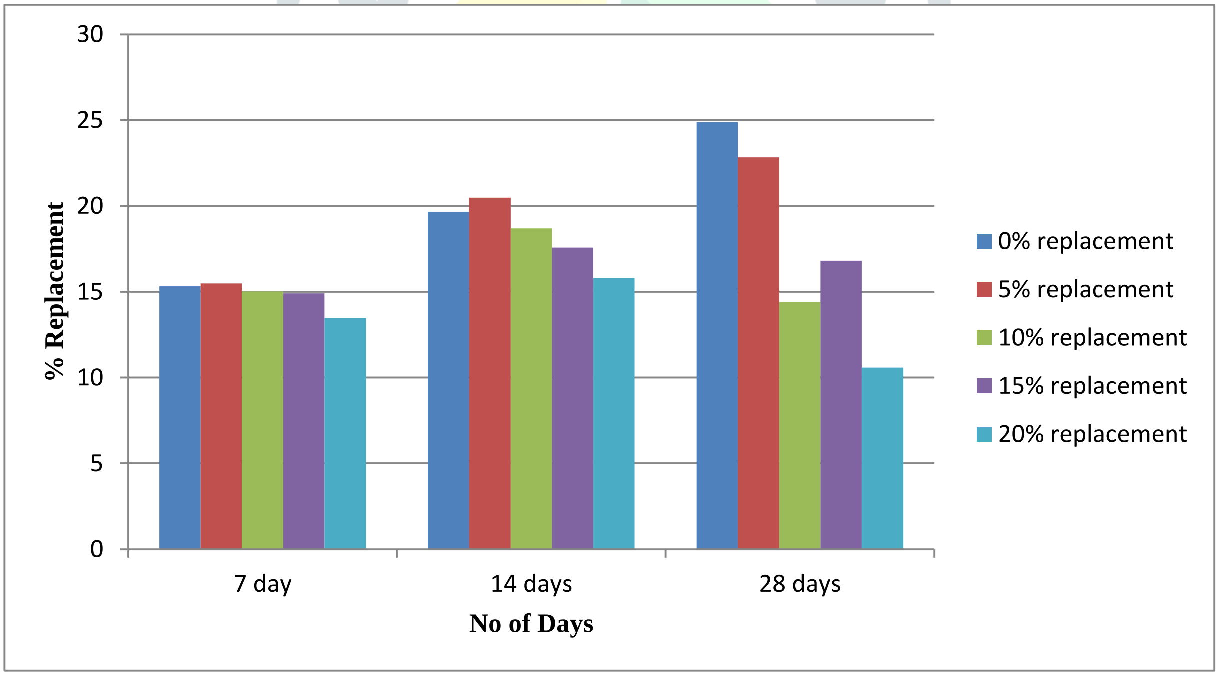

Fig 1: Bar chart representing the compressive strength of lightweight concrete by which cement is partially replaced by animal bone ash

DISCUSSION

In accordance with BS 4550 part 3, the standard maximum strength requirement for ordinary Portland cement for concrete is about 25N/mm^2 to 29N/mm^2 for 28 days curing period.

1. The compressive strength of the normal conventional concrete varies increasingly from 15.31N/mm^2 at 7 days then 19.69 N/mm^2 at 14 days and 24.89 N/mm^2 (highest) at 28 days.
2. At 5% replacement the compressive strength of the concrete increase from 15.49N/mm^2 at 7 days then 20.49N/mm^2 at 14 days and 22.83 N/mm^2 (highest) at 28 days.
3. The remaining of the 10,15 and 20% replacement are 15 N/mm^2 or lesser at 7 days then increase to above 15 N/mm^2 a little bit at 14 days then rapidly decline to below 15 N/mm^2 with the exception of 15% which is greater than 15 N/mm^2 (i.e.16.81 N/mm^2).

CONCLUSION

1. Pumice can be used in order to manufacture lightweight concrete with a high compressive strength even if its cement content has been partially replaced.
2. 5% replacement of cement with animal bone ash in a lightweight concrete can be used as our normal construction concrete nowadays due to its strength even though it is a little bit less strong than normal conventional concrete at 28 days of curing.
3. In lightweight concrete, strength decreases with increase in cement replacement (from 5% to 20%) even though it can be used in blinding and German floor.

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