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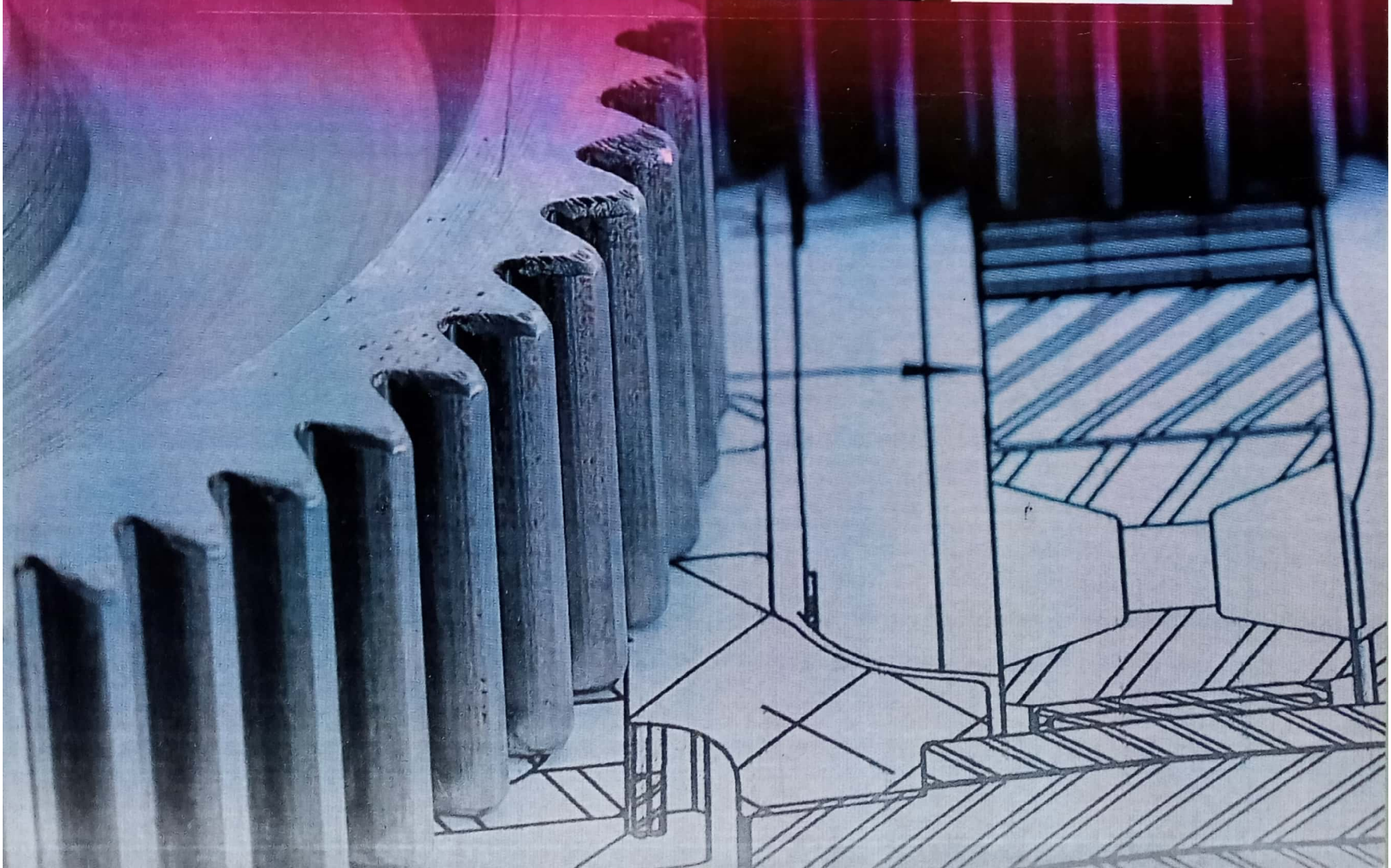

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Effectiveness of Powdered Cow-Bones as Pozzolana in Concrete Production

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Abstract
The effectiveness of powdered cow-bones as pozzolana on the compressive strength of concrete is evaluated in this study. The study is also an alternative to the high cost of concrete production due to the increasing cost of Ordinary Portland Cement (OPC), depletion of scarce natural resources and degradation of the environment through continuous calcination of cement manufacturing processes and most importantly utilization of cow bones, which is otherwise a waste material. Field survey was conducted to determine the availability of cow-bone followed by laboratory experimentation for the determination and analysis of the physical and chemical properties of powdered cow bones as pazzolan and effect of the properties on the strength of concrete. The results obtained from the analysis indicate that powdered cow bones is a pozzolanic material and contains all the oxides expected of pozzolans. Powdered cow-bones was subsequently used as a partial replacement of OPC in concrete production at levels of 0 (control), 10, 20, 30, 40 and 50 percent to produce concrete cubes, which were cured for 7, 14 and 28 days; and crushed. These results revealed that the strength of concrete reduced as the percentage replacement of the OPC in the samples increased. The optimum level of replacement was found to be 10 percent with associated and corresponding optimal concrete strength of 24.60 N/mm^2. However, 20 percent replacement of OPC with powdered cow bones gave a compressive strength of 18.22 N/mm^2. Therefore, it can be concluded from this work that provided the replacement level of OPC with powdered cow-bones does not exceed 20 percent and the developed corresponding optimal compressive strength of between 24.60 and 18.22 N/mm^2, then, such a concrete is within the allowable structural Grade 20 concrete. The study revealed that about 3million tonnes of cow bones can be converted into powdered cow-bone, which will be available for partial replacement of OPC in structural concrete production in the study area.

Keywords: Powdered cow-bones, Waste, OPC, Concrete, Compressive strength.

Introduction

Developing nations like Nigeria require massive investment in their basic infrastructure in order to achieve their goal of becoming one of the developed nations. Basic infrastructure includes good road network, communication, power, mass housing and agriculture. The provision of all these amenities especially mass housing and good road network requires a lot of concrete works. Concrete is a man-made product consisting of Portland cement as binder, aggregates as filler and water (Hornbostel, 1991; Mehta and Monteiro, 1993; Neville and Brook, 2003; Taylor, 2013). Cement, which is the chief ingredient in concrete, requires calcination and utilisation of natural resources to manufacture, and manufacturing process contributes to the high cost of cement. Aside being expensive, natural resources are being continuously depleted and the manufacturing process of cement releases large amount of carbon contents into the atmosphere, which also has some 'green-house effect on the environment. The negative effects from the production of cement is of great concern and these pose serious challenges to all the stakeholders in cement production globally. These reasons give rise to the search for alternative materials that can economically and partially or fully replace Portland cement in order to save the natural resources from being completely depleted, save the environment from the greenhouse effects by reducing the carbon content in the atmosphere and provide a cheap and affordable cement with equal or similar strength for use in the construction industry. Similar researches have been carryout in an effort to come-up with a binder that is affordable affordable (Ravindrarajah, 2001; Oyetola and Abdullahi, 2006; Javed *et al,* 2012; Noel *et al.,* 2015), with little or no depletion of natural resources and with less degrading effect on the environment. Also cow-bones constitute serious environmental problem of solid waste deposal. The use of powdered cow-bones for structural concrete production will help to convert the waste cow-bones into treasure thereby creating job opportunity, while creating an avenue for waste cow-bones conversion into powdered cow-bones as a pozzolanic material.

Agricultural and industrial by-products like saw dust, rice husk ash, glass, iron filing, paper, plastic, broken bottles, electronic waste, animal – cow dung and cow bones in pulverized form, are major materials that have been suggested for use in the search for alternative materials for Portland cement or as partial replacement for coarse or fine aggregates in concrete production (Ravindrarajah, 2001; Oyetola and Abdullahi, 2006; Falade *et al.,* 2012; Omoniyi, Dana and Mohammed, 2014; Dana and Omoniyi, 2014). A pozzolan is any material with siliceous or siliĉeous and aluminous materials which contains little or no cementitious properties, but in a very fine form and in the presence of water will react with calcium hydroxide, $Ca(OH)_2$, to form Calcium Silicate Hydrates (C-S-H) which is the strength forming product of Portland cement (Taylor, 1997; ASTM C618, 2005)

Research on waste re-usability for sustainability is on the rise and the subject is attracting global commendations due to its functional benefit in reducing construction cost considerably (Varzinskas Visvadas *et al.,* 2009). Oyetola and Abdullahi, (2006) carry-out an extensive research on rice husk ash in low-cost concrete production, and the results obtained at optimum replacement of cement with rice husk ash shows that the strength activity of the Ordinary Portland Cement / Rice Husk Ash (OPC / RHA) concrete increases as the curing age increases; but the reverse is the case when the percentage replacement of the ash increases. Oyetola and Abdullahi, (2006) suggested an optimum replacement level of 20% of RHA with OPC for structural concrete production. Similarly, research on concrete mix containing sawdust as an air entraining admixture for developing sawdust concrete for sandcrete block making was also carried out. The results obtained revealed that sawdust concrete for sandcrete blocks making, with optimum sawdust replacement of 30% and density of $1.920kg/m^3$, produced the best results for compressive strength (Falade, 1990).

Experimental study on Bamboo leaf ash revealed that the reaction of the ash with calcium hydroxide is pozzolanic in nature. The result showed that at 20% weight replacement of the bamboo leaf ash with Portland cement, there is no significant change in the compressive strength at 28 days of hydration of the concrete when compared with the control sample (Dwivedi *et al.,* 2006).

A study on the suitability of animal bones as partial or full replacement for normal coarse aggregates in concrete works has been carried out, and it was adjudged that animal bones are potential materials as coarse aggregate for lightweight concrete production (Javed *et al.,* 2012). The analysis of the strength tests showed that 50% optimum replacement of coarse aggregates by the crushed animal bones was quite satisfactory with no compromise in compressive strength requirements for concrete mix ratio 1:1.5:3 when the water/binder ratio was 0.45 (Javed *et al.,* 2012).

In the same vein, cow waste materials, such as, cow-dung have also been evaluated or used in construction works (Omoniyi, Duna and Mohammed, 2014; Thej- Kumar *et al.,* 2015). Little or not much investigations have been carried out on the possibilities of using cow-bone based materials as partial or full replacement for Portland cement in construction works. However, cow-bones are mostly used for fish feeding in fish farming (Kausar, 2009: Adewumi *et al.,* 2011)

The effectiveness of powdered cow-bones as pozzolana on the compressive strength of concrete is investigated in this study, necessitated by the high cost of concrete production due to the cost of cement, depletion of scarce natural resources and pollution of the environment through continuous calcination of cement manufacturing processes and most importantly cow bones as a waste.

Materials and Methods

Materials

Preliminary tests of materials were carried out in accordance with current British Standards (BS), European Codes (EC), American Standard of Testing and Measurement (ASTM) for conformity with these specifications.

Powdered cow-bones

Cow-bones were obtained from a major abattoir in the Federal Capital Territory (FCT), Abuja, Nigeria. Heavy and dense bones were separated from the lightweight bones. The selected bones were then sun dried to remove the fat or marrow that may affect the drying and results required. While sun drying, it was observed that the muscle tissues attached to the bones were making it difficult to dry easily. So the attachments were carefully removed to aid in quick drying of the bones. After one month of continuous drying, it was also noticed that fat or marrow inside the bone was not helping in drying the bones very well. The bones were crushed into pieces with the aid of a hammer and re-dried to enable the bones dry completely. The bones were later crushed in a milling machine and further milled to obtain a finer pulverized cow-bones. The fraction passing through sieve 75μm (No. 200) was stored in bags and kept in a cool dry place. The availability of cow-bones to meet the demand for its use was also investigated taking Abuja metropolis as a case study. It is of great importance to note that the powdered or pulverized cow-bones used as a pozzolanic material for this work was not powdered bones ash obtained through burning or incineration of cow-bones as already investigated by some researchers such as Abubakar, Abdullahi, and Aguwa, (2016), but pulverized or powered cow-bones obtained through milling of the cow-bones.

Ordinary Portland Cement

The Portland cement used for the research was obtained from a recent supply to the depot located in Minna, Nigeria and conformed to British Standard (BS) 12, (1996) specifications.

Fine aggregates

River sand which is free from impurities is used with dimensions less than 2.35 mm. The properties of the fine aggregates used conform to the requirements for graded standard fine-sand specification according to ASTM C778, (2002); and BS 882, (1973).

Coarse aggregates

Coarse aggregates of 20mm in size with crushed angular shape and free from dust was used in the concrete mix for both control and test samples Properties of the course aggregate used conform to the requirements for graded standard course Specification according to BS 882, (1973).

Water

Clean and portable water, free from germs and other impurities obtained from the Civil Engineering Department laboratory water tap of Federal University of Technology, Minna was used for the mixture. The water used was in conformity to BS 3148, (1980).

Methods

Physical and chemical properties of powdered cow bones

The physical and chemical properties of Ordinary Portland Cement, aggregates (fine and coarse) and powdered cow-bones have been carefully determined and analyzed in accordance to ASTM C618, (2005); ASTM C311, (2000) and ASTM C114, (2000) specifications and methods. Laboratory tests such as moisture content, loss on ignition, sieve analysis, specific gravity, fineness modulus, concrete proportioning, bulk density and water absorption (free water factor) have been conducted on the samples in accordance to the Specifications and methods (BS 812: Part 107, 1995;. BS 812: Part 2, 1995; BS 812: Part 103.1, 1985)

Consistency test on cement and powdered cow-bones

Standard method of determining the water requirement to achieve standard consistency of cement paste is in accordance with BS 12 (1996), using the Vicat probe and the Vicat apparatus was done by partially replacing cement with powdered cow-bones at various cement replacement levels ranging between 10 and 50% at 10% interval. Water demand for standard consistency is determined for each percentage replacement of cement with the powdered cow-bones. The water demand for zero replacement of cement with powdered cow-bone serves as the control. The same procedure was applied for the determination of setting times of Portland cement and powdered cow-bones. The control water cement ratio for the mixture is 0.45. Slumps for the respective displacements were measured and recorded.

Casting of concrete cubes

Cast iron mould of size 150 × 150 × 150 mm was used for casting the concrete cubes in preparation for compressive strength determination. The mould was assembled prior to mixing, cleaned and properly lubricated for easy removal of hardened concrete cubes. Concrete cubes were prepared in percentages by weight of powder cow-bones to cement in the order of 0%, 10%, 20%, 30%, 40% and 50% respectively. The concrete was mixed according to the design proportion and filled in 50 mm layers and compacted, with a steel tamping bar, with 30 tamps per layer into the 150 mm mould. After tamping each layer, the mould was tapped by the sides in order to close the top surface of each layer. The final layer slightly overfills the mould. Finally the top layer was troweled off and leveled with the top of the mould. Each of the mould was properly labeled and marked for easy identification. The fresh concrete was kept away from extreme heat and cold and allowed to set for twenty-four hours before introducing them into the curing tank. The above procedure was carried out in accordance with BS 1881: Part 115, 1983 and BS 1881: Part 116, 1983 specifications and methods. Five concrete cubes served for the control sample and five other replacements making a total of ninety (90) cubes. Each cube of three sets (30 cubes each) were weighed and crushed after curing for 7, 14 and 28 days respectively.

Results and Discussion

Availability of cow bones

The animal bones used for the investigation is limited to cow bone. The reason being that it is readily available and the statistics on its availability can be easily achieved considering the number of slaughter houses within reach. Cow bones are available in large quantities due to beef importance in food consumption in Nigeria. Almost all household consume cow meat daily. Restaurants, bars and recreation centres use cow meat in one way or the other. This increases the number of cows slaughtered per day. By using Federal Capital Territory (FCT), Abuja as case study, for the availability of cow bones, it was found that there are five slaughter houses where cow bones can easily be sourced. Table 1 present the location of the abattoirs in FCT and the average number of cows slaughtered per day. This result was obtained by going round the abattoirs to obtain first-hand information from the workers in the various slaughter houses.

Table 1: Location and Availability of Cow Bones

S/No	Slaughter houses	Average no. of cows slaughtered per day	Status
1	Kubwa	100	In Operation
2	Dei-Dei	180	In Operation
3	Karu	80	In Operation
4	Abaji	45	In Operation
5	Mpape Slab	25	In Operation
	Total Per Day	430	

There are four slaughter houses and one slaughter slab in FCT, Abuja, Nigeria. The combined number of cows slaughtered per day is about 430 cows as presented in Table 1. The quantity of bones from the total number of cows was obtained using the average weight of cow, percentage of bone from the total weight and total weight generated as waste. The analysis on quantity of cow bones that can be generated per day is presented in Table 2

Table 2: Analysis on Quantity of Cow-Bones that can be generated per day.

Description	Quantity
Number of Cows slaughtered Per Day	430
Average weight of a matured cow	350kg
Percentage of cow-bones in a matured cow	30-35% of total weight
Total weight of cows slaughtered per day	150,500kg
Percentage of cow bone generated as waste per day	45,150kg (30% of total weight)
Annual weight of cow bones generated in FCT	16,479,750.00 (16 Tonnes)

From Table 2, cow-bones annual generation of 16500 metric tonnes in FCT, Abuja, Nigeria were obtained excluding those that could be generated during parties, religious festivals and other ceremonies. Based on the cow-bones generation in FCT, Abuja, Nigeria the annual national generation can be conservatively put at about 4 million metric tonnes. Assuming two million is used for animal feeds and other manufacturing industries, the remaining about 2 million metric tonnes can be used for concrete production. This will definitely reduce the cost of Portland cement in construction and also serve as a way of evacuating and recycling cow bones waste from the environment, while at the same time creating job opportunities.

Physical properties of samples

The physical properties are measureable quantities of the samples which do not affect the structure of the molecule. Water content is used to determine the quantity of water in the sample. Densities are measured in reference to some standard materials (water and air) to give specific gravity of the sample. An empirical factor obtained by adding the total percentages of a sample of the aggregate retained on each of a specified series of sieves, and dividing the sum by 100 is used to determine the fineness and coarseness of the sample. Small value indicates a fine material, while a large value indicates a coarse material. The value for fine aggregates commonly ranges from 2.00 to 4.00 and for coarse aggregates from 6.50 to 8.00 (BS 882, 1973; ASTM C-778, 2002). One of the methods of selecting mixture proportions for concrete was based on the fineness modulus of the combined fine and coarse aggregate (Abrams, 1918). This concept was useful in describing particle-size distributions by an index number. Bulk density, water absorption and consistency were all determined. The result of the tests conducted on the physical properties of materials used is presented on Table 3.

Table 3: Physical Properties of Materials

Property	Cement	Powdered Cow-Bone	Sand/Fine Aggregate	Coarse Aggregate
Moisture Content	0.62	1.52	3.34	0.40
Fineness Modulus (%)	3.80	3.70	2.90	-
Maximum Aggregate size (mm)	-	0.075	2.36	20.00
Bulk Density (kg/m^3)	-	-	1400.00	1650.00
Specific gravity (S_sd)	3.15	2.11	2.60	2.68
Water Absorption (%)	-	<1	3	1

From Table 3, the fineness modulus for cement, powdered cow-bones and sand/fine aggregate are 3.80, 3.70 and 2.90, while the specific gravity for the materials are 3.15, 2.11, and 2.60 respectively. Also, the specific gravity of coarse aggregates is 2.68. All the values obtained and used are within the specified standard (ASTM C618, 2003; BS 12, 1996; BS 812, 1995; BS 882, 1983)

Chemical properties of powdered cow bones

The result of the chemical analysis of powdered cow-bones was carried out in accordance with ASTM C618, 2005; ASTM C311, 2005 and ASTM C114, 2000 at Federal University of Technology, Minna, Nigeria laboratory is as presented in Table 4.

Table 4: Chemical Composition (%) of Powdered Cow-Bones

S/N	Compound	Percentage contents (%)
1	CaO	44.3
2	SiO_2	7.45
3	Al_2O_3	0.82
4	Fe_2O_3	0.11
5	MnO	0.08
6	MgO	6.64
7	K_2O	0.46

8	Na_2O	1.71
9	SO_2	1.09
10	H_2O	1.52
11	CO_2	0.00
12	Pb	0.00
13	Cu	0.16
14	P_2O_5	13.80
15	Loss on Ignition (LOI)	1.95
16	Specific Gravity	2.11

The presence of siliceous and aluminous materials in cow-bones powder shows that when it is in its finely divided form, it can react with calcium hydroxide (CH) to form calcium silicates hydroxide (a strength forming product in cement), which is an indication that it is a pozzolanic material. The results were further compared with the specification in Table 1 of ASTM C618 (2002). The summation of the composition of silicon dioxide (SiO_2) plus aluminum oxide (Al_2O_3) and iron oxide (Fe_2O_3) is higher than 50%, which is the minimum, sulphur trioxide (SO_3) is not up to 5%, which is the maximum specified, moisture content is less than 3% the maximum value specified, loss on ignition is less than 6%, which is the maximum value specified for pozzolanic materials (ASTM, 2005).

It is also observed that the chemical composition of cow bones is almost the same to that of Portland cement. For example, CaO which is one of the main constituent of Portland cement is also a major constituent in cow bones. Other compounds in Portland cement like SiO_2, Al_2O_3, Fe_2O_3, MnO and MgO are also present in powdered cow bone. This suggests that though cow bones may have similar chemical contents, yet its cementitious value cannot be compared with that of Ordinary Portland Cement, because it is an organic. Other observations made from the chemical analysis include high calcium content in powdered cow bones, thus suggesting it as a pozzolanic material like class C type of fly ash. The loss on ignition, a measure of the extent of carbonation and hydration of free lime and free magnesia due to atmospheric exposure of cow bones is 1.95%. This value is within the limits of 3.0% as set by BS 12 (1996).

Strength index

Strength activity index with Ordinary Portland Cement is higher than the minimum value set by ASTM C618, 2005. Therefore, it is concluded that cow bones generally may be used as a pozzolanic material. The result of the investigation obtained on the pozzolanicity of powdered cow bones was compared with ASTM C618, (2005) as presented on Table 5.

Table 5: Chemical and Physical Requirement of Pozzolana

Properties	Class N	Class F	Class C	Cow bones powder
Silicon dioxide (SiO_2), plus Aluminium oxide (Al_2O_3) plus Iron Oxide (Fe_2O_3), min (%)	70.0	70.0	50.0	52.68
Sulphur trioxide (SO_3), max (%)	4.0	5.0	5.0	1.09
Moisture Content, max (%	3.0	3.0	3.0	1.59
Loss on Ignition max %	10.0	6.0	6.0	2.24
Fineness: Amount retained when wet sieved on 45μm (No. 325) sieve, max (%)34		34	34	28.92

From Table 5, the percentage compositions of Silicon dioxide (SiO_2), Aluminum oxide (Al_2O_3) and Iron Oxide (Fe_2O_3) sums up to 52.68%; while the composition of Sulphur trioxide is 1.09%, moisture content and loss on ignition obtained are 1.59 and 2.24 respectively. The major requirements of the specification for pozzolana as compared with the result of the investigation shows that cow bones satisfy the requirements of a pozzolana.

Design mix

The summary of the design mix proportion for one cubic meter batching and quantity for the required cubes needed are presented in Tables 6 and 7. There are five cubes of concrete for each replacement and using concrete mould of 0.003375m^3 (0.15m x 0.15m x 0.15m), we obtain a total volume of 0.016875m^3 for the five cubes. Adding 15% to the volume to take care of wastages gives the total volume for each component to be 0.1856m^3 for the batching.

Table 6: Summary of Mix Design Result for One Cubic Meter of Concrete (Kg/m^3)

Percentage Replacement	Cement	Water	Animal Bone	Fine Aggregate	Coarse Aggregate	Total Weight
0	442.00	199.00	0.00	759.00	990.00	2390.00
10	397.80	199.00	44.20	741.00	990.00	2372.00
20	353.60	199.00	88.40	723.00	990.00	2354.00
30	309.40	199.00	132.60	705.00	990.00	2336.00
40	265.20	199.00	176.80	686.40	990.00	2317.40
50	221.00	199.00	221.00	668.20	990.00	2299.20

Table 7: Summary of Mix Design Result for a batch of concrete (Kg/m^3)

% Replacement	Cement	Water	Animal Bone	Fine Aggregate	Coarse Aggregate	Total Weight
0	8.22	3.70	0.00	14.11	18.41	44.45
10	7.40	3.70	0.822	13.78	18.41	44.10
20	6.58	3.70	1.64	13.45	18.41	43.78
30	5.75	3.70	2.47	13.11	18.41	43.45
40	4.93	3.70	3.29	12.77	18.41	43.10
50	4.11	3.70	4.11	12.43	18.41	42.77

Various batching were prepared for 7, 14 and 28 days compressive strength test procedures respectively.

Water demand consistency and setting times

Although the whole concrete mixture had the same water / cement w/c) content of about 0.45, it was observed that as the replacement percentage increases, the slump increases and the paste became more workable. This shows that the paste with animal bones replacement need less water to achieve the same consistency with the control sample. The use of pulverized bones increased the setting time of the paste. The delay in setting time is about 30% of normal setting time. This trend increases as the percentage replacement increases. The experiment does not contain pastes with 100 percent replacement of animal bone so it cannot be deduced if such a paste will set.

Compressive strength

Compressive strength results on the three curing ages of concrete of 7, 14 and 28ays considered are as presented Table 6 and the relationship of the compressive strength to days of curing and content of cow- bones are presented in Fig. 1.

Table 6: Compressive Strength at Various Ages of Curing

Cow Bone Replacement (%)	Compressive Strength (N/mm^2)		
	7 Days	14 Days	28 Days
0	19.10	25.30	31.19
10	14.56	19.80	24.60
20	9.85	14.31	18.22
30	8.79	11.86	15.16
40	5.93	8.88	11.21
50	3.91	6.03	7.67

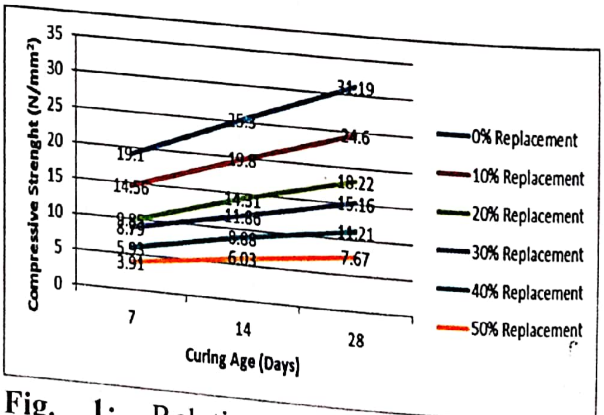

Fig. 1: Relationship of compressive Strength with curing age.

It is generally observed from Fig. 1 that the strength of concrete reduces as the percentage replacement of animal bones increases. It reveals that cow bones do not contain cementitious material even though the material contains some compounds that are similar to that of Ordinary Portland Cement. The mixture with higher cow bones proportion is much lower in strength when compared to the control sample. At 28 days and 10% replacement, the strength decreases from 31.19N/mm^2 to 24.60N/mm^2 for the control and test samples. The difference in strength between the control sample and 10% replacement sample is considered minimal and tolerable. Considering the fact that the calcium hydroxide which is a by-product released from the hydration process of cement in concrete becomes available after a certain period of time. Continuous release of calcium hydroxide will continue to act with the pozzolana to add more strength to the concrete. The result proves that the strength of concrete is not affected when cement is replaced with powdered cow bones by 10%.

Conclusion and Recommendations

Conclusion

Based on the findings from analysis of the results obtained on effectiveness of powdered cow-bones as pozzolana on the compressive strength of concrete, it can be concluded that:

Cow-bone is readily available in large quantities and the statistic on its availability can easily be achieved considering the number of slaughter houses within reach for use as replacement of OPC. Consequently, there will be reduction in the price of concrete when cow bones are incorporated in concrete production, and that the availability of cow bones due to annual cow meat consumption reveals that about 2 million tonnes of cow bones can be converted to pulverized cow bones for partial replacement in concrete production

Powdered cow-bones is a natural pozzolan since it does not requires calcination to exhibit its pozzolanic characteristics, contains all basic composition of oxides, and belong to Class C type of pozzolan.

Powdered cow-bones requires less amount of water to achieve the same consistency with the same amount of Ordinary Portland Cement, therefore powdered cow-bones can be incorporated with Ordinary Portland Cement at partial replacement to make concrete provided the replacement is not more than 10%.

Strength of concrete decreases as the percentage replacement increases. The optimum level of replacement is found to be 10 percent with associated and corresponding optimal concrete strength of 24.60 N/mm^2. However, 20 percent replacement of OPC with powdered cow-bones gave a compressive strength of 18.22 N/mm^2. Therefore, provided the replacement level of OPC with powdered cow-bones does not exceed 20 percent and the developed corresponding optimal compressive strength of between 24.60 and 18.22 N/mm^2, then, such a concrete is within the allowable structural Grade 20 concrete.

Agro-waste from cow bones can be eliminated from the environment if the result herein is put into use, and also a great number of employments can be generated from cow bones processing into powder for concrete mixture.

Recommendations

Based on the results and analysis of the effectiveness of powdered cow bones as pozzolan on the compressive strength of structural concrete, the following recommendations are made:

(i) The results obtained can be applied in concrete production in order to achieve green environment.

(ii) Further research can be undertaken on longer age of testing and curing say 56 days to 98 days. Since pozzolanic reaction actually takes place after the release of calcium hydroxide from the hydration process of cement which takes a longer period than in this study;

(iii) Smaller percentages say multiples of 5% interval can be encouraged. This will enhance proper and clearer picture of results.

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