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Strength Evaluation of Corn cob ash in a blended Portland cement

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ABSTRACT: - The paper investigates the characteristics of corn-cob ash (CCA) in uncompacted concrete. The structural value of the composite was evaluated with consideration for its suitability in concrete. Varied percentage of corn-cob ash at 0%, 10%, 20%, and 30% replaced cement in 1:2:4 concrete mix. Tests were carried out to determine the chemical composition of CCA in comparison with ordinary portland cement (OPC), while mechanical test such as specific gravity test, absorption test of aggregate, particle size distribution test of aggregate werealso carried out. Compressive strength of hardened cured (150 x 150 x 150) mm concrete cubes at 7days, 21 days and 28 days were tested. The results showed that at 30% CCA, the compressive strength was 18.44N/mm^2.This research showed that up to 30% replacement of cement with CCA is feasible.

Key words: **Uncompacted concrete, aggregates, cement, corn-cob ash, compressive strength.**

I. INTRODUCTION

Cement concrete is the most widely used building material due to its satisfying performance in strength requirements and its ability to be moulded into a variety of shapes and sizes. Therefore the utilization of corncob ash reduces cost of production of cement. In recent times, the knowledge of natural pozzolanic materials used as partial replacement for cement has increased substantially, it is however expedient to find a suitable replacement for the cement in the form of waste-to-wealth. Corncob is the hard cylindrical core that bears the kernels of an ear of corn, usually an agricultural by-product found after removal of the corn.(2) described corn cob as the agricultural waste product obtained from maize or corn; which is the most important cereal crop in sub – Saharan Africa. Earlier investigation as revealed by (2), showed that compressive strength of concrete increased significantly up to 10%replacement of OPC with CCA, however the CCA was prepared from open-air burning to produce the ash as carried out by (15) (15) concluded in their investigation that Concrete strength increases with curing age and decreases with increasing percentage of corn cob ash and that Corn cob ash concrete do not attain their design strengths at 28days. It is noted that reactivity of agricultural wastes as investigated and revealed by (7)is usually between 500^{o}C to 700^{o}C as also revealed by (10) investigations. They identified the temperature range of 500^{o}C to 700^{o}C as optimum reactive ash formation. Pioneer research of (12),(8)(16) and(4) achieved not more than 10% partial replacement of OPC in 1:2:4 concrete mix with CCA. However, all these researchers worked with CCA prepared from uncontrolled burning. (8)Investigated the influence of (CCA) average particle size on the properties of concrete and found that at early ages the strength was comparable, while at the age of 28days, CCA produced concrete exhibited higher strength than the sample with OPC. (4), concluded in their investigation that upto 10% replacement of CCA in OPC is suitable to achieve the desired results. (2), established the pozzolanic properties of CCA. Mass concretes under water are mostly uncompacted and may draw from the advantage from the pozzolanic properties of CCA. The current research is to explore the impact of preparation of CCA under controlled burning of 600^{o}C for 2 hours on partial replacement of OPC in uncompacted 1:2:4 concrete mix.

II. MATERIALS AND METHODS

The materials used for this research were Corn cob ash (Fly ash), Portland cement conforming to ASTM type 1, Sand (Fine aggregate), Granite (Coarse aggregate) and clean and deleterious-free water. The corn cobs were obtained from farm steads in Ago aduloju area of Ado-Ekiti. They were sun-dried and later burnt in a furnace at temperature of 600^{o}C for 2 hours to obtain the ash, which was later subjected to sieve analysis to determine the particle size distribution and the amount passing 75µm sieve used for the concrete mix. Chemical analysis of CCA was done in Science laboratory of school of Technology, Federal Polytechnic, Ado-Ekiti. Portland cement was partially replaced by Corn cob Ash (CCA) in a mix of 1:2:4 to determine the workability of the concrete and other tests including the determination of compressive strength for 7, 21 and 28 curing days at different mix proportions. These were carried out according to (1) to achieve the desired result. The compressive strength tests, on the samples were conducted in concrete laboratory, Civil Engineering Department, Federal Polytechnic, Ado-Ekiti. The mix ratio used was 1:2:4 at different nominal replacement of OPC with CCA and water cement ratio of 0.5 by weight, 36 cubes for compressive strength samples were casted for varied percentage of controlled burnt CCA in a 0%, 10%, 20% and 30% percent replacement of OPC. For each replacement level, three test cubes were casted and the average found to represent the entire samples. The cubes were tested for compressive strength after 7, 21 and 28 days curing.

III. RESULTS AND DISCUSSION

Chemical Analysis of Corn Cob Ash (CCA)

Chemical analysis was carried out on samples of CCA and ordinary Portland cement (OPC) to reveal and

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compare their composition, and the result is as shown in Table 1. The percentage composition of the constituent compounds in the CCA is compared to that of typical ordinary Portland cement (OPC). The results show that CCA contains most of the compounds known to have binding properties necessary for concrete work. The percentage composition of CaO and SO_3^{2-} found in the CCA was found to be less than that in the OPC. The total percentage of iron oxide (Fe_2O_3) silicon. dioxide, (SiO_2) and aluminum oxide (Al_2O_3) is found to be more than the minimum of 70% specified for pozzolanas by (3) However, the percentage content of magnesium oxide was found to be much higher than the minimum recommended.

Table 1: Chemical composition of CCA and OPC.

Constituents	Percentage (%) (CCA)	Percentage (%) (OPC)
(SiO_2)	56.39	22.0
(Al_2O_3)	17.57	5.02
(Fe_2O_3)	9.07	4.65
(CaO)	11.47	62
(MgO)	0.98	2.06
(SO_3^{2-})	0.55	1.43
(K_2O)	1.98	0.4
(Na_2O)	1.91	0.19

Particle Size Distribution

Sieve analysis was carried out on 300g of river sand sample. The fine aggregate passed through 5mm sieve as recommended. Before the sand was used it was dried to remove the moisture content so that it will not increase the water content in the concrete mix and the results shown in table 2 and 3. The results revealed the sand sample was well graded falling into zone 2 near border of zone 1, which is very appropriate for concrete work in accordance with (5) test sieves.

Table 2: PARTICLE SIZE OF FINE AGGREGATE.

Sieve size	Weight retained {g}	Amount retained {%}	Amount passed {%}
9.50mm	0	0	100
4.75mm	9.0	1.8	98.2
2.36mm	17.8	3.6	94.6
1.18mm	55.5	11.1	83.5
600microns	129.8	26.0	57.5
425microns	71.6	14.3	43.2
300microns	100.2	20.0	23.2
150microns	93.6	18.7	4.5
75microns	10.1	2.0	2.5

Table 3: PARTICLE SIZE OF COURSE AGGREGATE.

Sieve size {mm}	Weight retained {g}	Amount retained {%}	Amount passed {%}
25	0	0	100
20	68.2	6.8	93.2
12.5	345.1	34.5	58.7
9.5	257.1	25.7	33.0
4.75	260.2	26.0	7.0

Specific Gravity

The specify gravity test conducted on the materials revealed the specific gravity of CCA as 2.27. This value is less than the value for cement which is 3.12 but however, it falls within the recommended range of 1.9 and 2.4 for pulverized fuel ash as stipulated in ASTMC-218. It was also found out that the specific gravity of corn cob ash, sand and granite was found to be 0.9, 2.65 and 2.75 respectively which are very close to the values seen in literature.

Absorption of aggregates

The absorption test conducted on the fine and coarse aggregates are 1.10% and 1.8% respectively. The result also conforms to the ASTM C-217.

Compressive Strength Test

Table 4 below showed the summary of the compressive strengths at different curing days for each mix, while Figure 1.0, and further illustrates the inter-relationship between each percentage of cement replacement with CCA against the compressive strength for different curing days. The results indicate that maximum compressive strength of 9.04N/mm^2, at 7 days curing occurred at a mix of 30%CCA, while that of 21 days occurred at a mix of 30%CCA having a value of 10.89N/mm^2 and that of 28 days showed maximum compressive strength to be18.44N/mm^2 at 30%CCA.

Table 4: Summary of Compressive Test Results

COMPRESSIVE STRENGTH N/mm²	CCA CONTENT IN %	COMPRESSIVE STRENGTH N/mm²	CCA CONTENT IN %	COMPRESSIVE STRENGTH N/mm²	CCA CONTENT IN %
7 DAYS		21 DAYS		28 DAYS	
8.3	0	10.59	0	17.78	0
8.74	10	10.67	10	17.7	10
8.67	20	10.74	20	17.11	20
9.04	30	10.89	30	18.44	30

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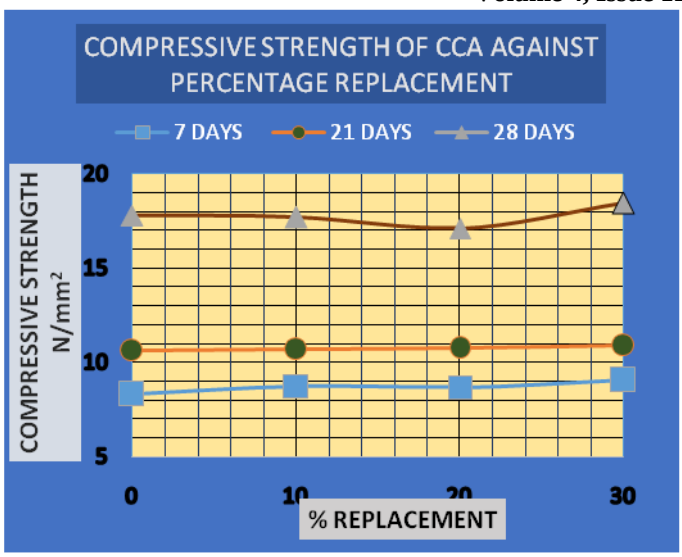

FIG. 1. COMPRESSIVE STRENGTH

IV. CONCLUSION

This research showed that with increasing percentage of CCA in a 1:2:4 concrete mix replacement of OPC, compressive strength increases. This research further showed that higher percentage CCA more than 10% can be used to replace OPC in concrete mix of 1:2:4. The conclusion however is that Corn cob ash produced at a regulated and controlled temperature have played an important role in achieving improvement in percentage replacement of OPC in concrete mix of 1:2:4. Based on the 28 days compressive strength results of 18.44N/mm^2, the designed mix of 30% CCA replacement of OPC in uncompacted 1:2:4 concrete mix would be useful in mass concrete work and other light weight reinforced concrete works.

V. RECOMMENDATIONS

This research recommends the following:

1.) The percentage replacement level should be increased to 50% at a step of 5%

2.) The chemical resistance of CCA blended cement should be examined to determine the suitability in harsh environmental condition.

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