e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 6, Issue 9, September 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.54

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.54| Monthly Peer Reviewed & Referred Journal |

| Volume 6, Issue 9, September 2023 |

| DOI:10.15680/IJMRSET.2023.0609002 |

A Comprehensive Review on the Engineering Properties of Cow Dung Ash in Concrete Production

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ABSTRACT: Cow Dung Ash is a pozzolanic material that is generated by burning cow dung cake at a controlled temperature. Concrete is a construction material that is made of aggregates, binder (cement) and water. The use of CDA in concrete production will help to reduce the environmental pollution caused as a result of the production of Portland cement. The present study helps to review the properties of cow dung ash as a supplementary cementitious material in concrete production. In this study, the pozzolanic activity of Cow dung ash was determined and the strength characteristics of cow dung ash concrete were compared with conventional concrete. Based on test results from the reviewed papers, the following conclusions were made. The use of Cow dung ash in concrete reduced the cost of materials for the production of concrete. The optimum replacement of concrete from reviewed papers suggested 20% cow dung ash, which increased the compressive strength of the concrete than conventional concrete. The workability decreases with an increase in percentage replacement. Durability tests showed that CDA concrete had better resistance to acid and sulphate attacks compared to normal concrete. More quantity of water was recommended in the concrete mix containing CDA concrete to make it a workable concrete.

KEYWORDS: Cow Dung Ash, Pozzolanic, Strength, Durability, Compressive Strength.

I. INTRODUCTION

Concrete is a widely used composite construction material in the building industry. It is made up of cement/binder, water and aggregates. The rapid increase in the cost of cement particularly in developing countries has made it hard for people who are low-income earners to own houses (Omoniyi *et al.,*2014). For instance, cement is sold for N 4,500 per 50kg bag which has become out of reach to low-income earners. According to Ayuba *et al.,* (2012), the exorbitant cost of cement production is one of the factors that has made housing developers build or construct structures with low-quality construction material such as concrete. Low quality of concrete produced due to hike in prices of cement manifests in weak sub-structures and super-structures may lead to failures, total collapse of buildings and loss of lives and property (Ayuba *et al.,* 2012). Greenhouse gas emissions from cement production and the mining of raw materials are the greatest environmental impacts of concrete. The production of one tonne of Portland cement emits approximately 0.9 tons of CO_2 into the atmosphere (Nazeer and Kumar, 2014). It was agreed that the production of Portland cement clinker is much more expensive and ecologically harmful according to results from various researchers (Mehta, 2001). There is an urgent need to search for supplementary cementitious materials which can fully or partially replace cement. This effort can help in reducing the amount of CO_2 emissions emitted during cement production. Agricultural and industrial wastes pose great hazards to the environment and man as a result of improper management even when these wastes are burnt. They release CO_2 into the atmosphere which also depletes the ozone layer (Elinwa and Abdulkadir, 2016). If these wastes are processed, they are useful for construction purposes (Turgut, 2007). Also, most researchers in the construction industry are doing their best to minimize the cost of construction materials by the use of available local materials in the area (Joshua *et al*, 2014). Replacing Ordinary Portland Cement with some percentages of pozzolana has been reported as a good alternative for partially replacing cement in concrete.

Currently, research efforts have been geared towards the use of local alternative construction materials including agricultural wastes and residues as construction materials. They provide resistance to all sulphate attacks and alkali-silica reactions. Materials such as Rice Husk Ash, Cow Dung Ash (CDA), Fly Ash, Slag, and Silica Fume can be used as a partial replacement for cementing material (Ojedokun *et al.,* 2014). Cow dung ash and Rice husk ash

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production which are cementitious materials are in abundance in Northern Nigeria and can be used as partial replacements for cement in concrete production.

II. LITERATURE REVIEW

2.1 Cow Dung Ash (CDA)

Cow belongs to the cattle family commonly available in all parts of the world. They are used for field operations like ploughing, harrowing, planting inter-cultivation etc., while some are used as sources of meat, dairy products and in the production of manure.

Cow dung is obtained from cow excreta, and dried in sunlight to form dung cake. The ash is produced by subjecting the cake to burning after drying by a process called calcination. The ash is a pozzolanic material and is very useful in the partial replacement of cement in concrete. Cow dung is obtained from cow excreta which is dried in sunlight to form of cake. Rayaprolu and Raju (2012) studied the use of cow dung ash as supplementary cementing material in mortar and concrete. The material can be used for the partial replacement of cement. Jitender and Surendra (2015) replaced cement using fly ash and cow dung ash. revealed that fly ash and cow dung ash can be used as partial replacements for cement in concrete.

2.2 Physical and Chemical Properties of Cow Dung Ash

Vasu., (2019) stated the physical properties of Cow Dung Ash as follows:

(1) It is very bulky.

(2) It generates large ash content.

(3) Low volatile content after burning.

(4) It gives low carbon content and a Burning Ratio.

Table1: Chemical Composition of Cow Dung Ash.

Oxide Composition	Percentage Composition				
	Source 1	Source 2	Source 3	Source 4	Average
SiO_2	69.76	69.65	61.786	61.866	65.765
Al_2O_3	4.74	4.27	5.206	3.614	4.4575
Fe_2O_3	3.18	2.99	3.978	2.502	3.1625
CaO	13.25	12.55	13.307	12.852	12.989
MgO	2.12	2.22	1.779	1.952	2.0177
SO_3	0.89	1.36	0.705	0.807	0.9405
K_2O	2.71	2.94	2.674	3.011	2.8337
Na_2O	0.611	0.56	0.388	0.485	0.511
P_2O_5	1.37	1.48	1.215	1.466	1.3827
Mn_2O_3	0.62	0.63	0.565	0.582	0.5992
TiO2	0.38	0.34	0.443	0.312	0.3687
$CaCO_3$	23.64	22.40	23.751	22.938	23.182
$SiO_2+Al_2O_3+Fe_2O_3$	77.68	76.91	70.97	67.982	73.385

Source: (Duna and Omoniyi, 2014).

2.3 Engineering and Pozzolanic Properties of Cow Dung Ash.

Netim and Niharika (2021) conducted a study on the use of Cow Dung Ash and Rice Husk Ash as partial replacement of cement in concrete. The experiments were conducted to study the effects of adding Cow Dung Ash and Rice Husk Ash in several percentages by weight (0%, 5%, 10%, 15%, and 20%) of cement and cured for periods of 28 days. The consistency, workability and sieve analysis of aggregates were checked. Compressive strength was tested and the results were 37.75 N/mm^2, 31.25 N/mm^2, 31.25 N/mm^2 and 25.25 N/mm^2 respectively. Workability results are 45mm, 49mm, 56mm, 68mm and 75mm respectively for 0%,5%, 10%, 15%, and 20% replacement of cement with Cow Dung Ash and Rice Husk Ash. The consistency test results are 0.29, 0.32, 0.36, 0.41 and 0.43 for 0%, 5%, 10%, 15% and 20%. The bulk density results are 2452.53kg/m^3, 2370.8 kg/m^3, 2380.0 kg/m^3 and 2348.5 kg/m^3 for 0%, 5%, 10% and 15% replacement of cement with Cow Dung Ash and Rice Husk Ash respectively. The results show that more quantity

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of water is required for standard consistency as the percentages of Cow Dung Ash and Rice Husk Ash are added. Dung Ash and Rice Husk Ash concrete is recommended for use when ten percentage (10%) of Cow Dung Ash and rice husk ash are not exceeded.

Veera and Chaitanya (2020) compared the pozzolanic activity and the strength characteristics of cow dung ash concrete and conventional concrete. The design mix M30 grade concrete was considered as a reference mix. Cement was replaced with cow dung ash in incremental percentages of 5%, 10%, 15%, and 20% by weight. The compressive strength of concrete was determined at 7 and 28 days of curing while the split tensile strength of concrete was determined at 28 days of curing. The results of the compressive strength showed that concrete made with 15% replacement of cement with cow dung ash performed well.

Vasu (2019) conducted experimental work on the partial replacement of cement by Cow dung ash (CDA) in the range of 5%, 10%, 15% and 20% by weight of cement for M20 grade mix. Specimens were made and tested for compressive strength at the age of 7, 14 and 28 days. The result showed that a 10% replacement of cement by cow dung ash makes a considerable increase in the compressive strength of concrete. The investigation has also shown that an addition of 10% CDA to concrete makes it stronger and more durable when compared to conventional concrete.

Ayeni and Akinlolu (2018) used Cow Dung Ash as a partial replacement for cement in concrete production. The replacements varied from 0%, 5%, 10%, 15%, 20%, 25% and 30% with water-cement ratios ranging from 0.54, 0.57, 0.60, 0.64, 0.68, 0.72 and 0.77 respectively. The mixing ratio was 1:2:4 was adopted for casting the specimens. The result of the chemical analysis conducted on cow dung ash shows that it is a pozzolanic material. The workability results are 20mm, 18mm, 17mm, 15mm, 14mm, 11mm, and 10mm for CDA with 0%, 5%, 10%, 15%, 20%, 25% and 30% replacements. The compressive strength of concrete was tested. Replacement up to 20% meets the strength requirement (17N/mm^2) for lightweight concrete.

Fredrick *et al.* (2018) studied the permeability properties of Cow Dung Ash concrete. Concrete cube samples with a mix design strength of 25N/mm^2 and a w/c ratio of 0.6 were produced by replacing cement with CDA at 0%, 10%, 20% and 30%. The result showed that the control samples had greater early strength as compared with that of the CDA samples. Low strength development was observed as a result of the presence of CDA as filler in the concrete. The results also indicated a decrease in flexural strength as CDA percentage content increased. The optimum replacement of 10% for compressive strength, flexural strength and water permeability was recommended. It was concluded that CDA is a very good pozzolan which can attain up to 93.64% design strength at 28 28-day curing period but increases the ingress of moisture into concrete when used but at 10% partial replacement the effect will not be of great concern. The compressive strength of concrete produced with cow dung ash mixed with glass fibre for the M25 mix design increased up to 8% replacement of cement by cow dung ash (Mathew *et al.,* 2017).

Okello *et al.,* (2017) used cow dung and local brewery waste in partial replacement of cement for plastering low-cost houses. The result established the good potential of using cow dung and local brewery waste as plastering material.

Ojedokun *et al.* (2014) studied the use of cow dung ash in concrete production. Cow Dung Ash replaced cement from 10%- 30%. Curing and testing for compressive strength were done at 7,14 and 28 days respectively. The experimental result recommends the use of CDA at 10%. They recommended the use of CDA for certain floors and walls which are not subjugated to the heavy loads and not to be used for structures related to the water.

Omoniyi, *et al.,* (2014) revealed that the initial and final setting time of concrete increased by 12.2%-59.3% and 2.74%-43.90% respectively as the % of CDA increased. This indicates that CDA is a set retarder.

Pavan *et al.* (2012) reported in their research "Incorporation of Cow Dung Ash to Mortar and Concrete" that workability, setting time and standard consistency increased with an increase in CDA content. The conclusion from the study showed that cow dung ash will be a supplementary cementing material in mortar and concrete.

Chetan *et al.,* (2021) said Cow dung is undigested residue of plant matter. It is rich in minerals like Sodium, Potassium, Magnesium and Manganese. Cow dung ash is an eco-friendly cheaper material. Partial replacement of cement with cow dung ash by weight at 5%, 10%, 15% and 20% in concrete shows remarkable results. The researchers replaced cement with a 10% additive with an increase in the same percentage of CDA. The best result was obtained by replacing cement with a 10% additive as cow dung ash for the production of concrete.

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2.4 Slump Values of CDA-Concrete

Table 2: Slump values for cow dung ash.

Percentage for CDA replacement (%)	CDA slump result (mm)
0	63
5	67
10	71
15	75
20	81

2.5 Durability Test

The durability study of concrete is very important for controlling and recording the durability performance of concrete under different environmental conditions. The two main tests carried out to determine the durability of concrete are the acid attack test and the sulphate attack test. Table 2 shows the percentage mass loss of concrete due to exposure to an acidic environment. CDA concrete specimens lost strength of 16.2% after 28 days as against OPC concrete specimens that lost 20.2 % after 28 days of immersion. CDA concrete specimens soaked in the H_2SO_4 solution lost compressive strength of 44.2% after 28 days of immersion as against OPC concrete specimens that lost 52.8% after 28 days of immersion.

Table 3: Acid attack test

Mix	Acid attack		% Weight loss	Compressive strength in MPa	
	Saturated dry weight				
	Weight before exposure	Weight after exposure		Strength before exposure	Strength after exposure
CDA 0	2.620 kg	2.09 kg	20.2	39.25	18.5
CDA 15	2.580 kg	2.16 kg	16.2	45.62	25.42

Source: Veera and Chaitanya, (2020)

III. CONCLUSION

The following conclusions are made from the review

(1) Cow dung ash is an eco-friendly cheaper material. The use of Cow dung ash in concrete reduces the cost of materials for the production of concrete.

(2) The optimum replacement of concrete is 20% cow dung ash, which increases the compressive strength of the concrete than conventional concrete.

(3) The workability decreases with an increase in percentage replacement, CDA concrete requires more quantity of water to be workable concrete.

(4) The use of CDA helps in the reduction of the cost of building and energy consumption.

(5) Durability tests showed that CDA concrete had better resistance to acid and sulphate attacks compared to normal concrete.

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Impact Factor
7.54

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