International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

An Experimental Study of Cow Dung Ash in Mortar

*Priyanka Kumari **B.P.Mudgal, ***Manoj Sharma
*M.Tech. Students, IPS College of Technology & Management Gwalior M.P.
** Professor, IPS College of Technology & Management Gwalior M.P.
***Professor, IPS College of Technology & Management Gwalior M.P.

ABSTRACT:
This study investigated the effects of using cow dung ash (CDA) as a partial replacement for ordinary Portland cement (OPC) in mortar. Mortar mixtures are made by replacing OPC with different amounts of CDA: 5%, 10%, 15%, 20%, 25% and 30%. The chemical composition of CDA consists mainly of SiO2, Al2O3 and Fe2O3, indicating a significant ignition loss. The workability, hardening properties and microstructure of mortars containing CDA are also analyzed. As the CDA content in the mortar increases, workability decreases, and above 5%, water absorption increases due to the porosity of CDA and the inability to remove organic compounds. This affects the density and compressive strength of the hardened mortar, compromising its homogenous properties. Using 5 Å, the bulk density and compressive strength of the mortar are comparable to the control mixture. However, both the bulk density and compressive strength of the mortar decrease with increasing CDA content. The thermal stability of 10%, 20% and 30°A mortar mixtures remains unchanged at temperatures between 500°C and 600°C. Fourier transform infrared spectroscopy (FTIR) analysis revealed the presence of unparalleled particles and extensively extended C-S-H gels in the mortar samples. In general, the results indicate that CDA can be used as a replacement for OPC at levels up to 10% in the production of mortars and can act as a replacement for cementitious materials.
Keywords: cow dung ash; mortar; microstructure; workability; durability; sustainability;

Introduction

In recent years, researchers have studied the potential of cow dung ash (CDA) as a supplementary cementitious material. Cow dung, a byproduct of cattle farming, is known for being a rich source of silicon dioxide, and thus has pozzolanic properties. It also contains organic matter, including fibrous materials that have passed through the cow's digestive system. The chemical composition of cow dung typically consists of carbon, nitrogen, hydrogen, oxygen, and phosphorus, as well as potassium and calcium.

Ekasila et al. investigated the effectiveness of using 10% CDA and 20% rice husk ash (RHA) in concrete under varying curing conditions. The researchers concluded that incorporating both SCMs in the concrete resulted in greater strength. Another study was conducted to evaluate the performance of concrete with 15% CDA that was exposed to water. The specimens were cured for 28 days and then exposed to fresh water for different durations of time: 56, 90, 180, and 365 days. The results showed that the concrete with CDA had superior pH, compressive and split tensile strength, and durability compared to normal concrete.

The researchers also observed a lower bacterial density in the CDA-containing concrete., India has a significant population of cattle, ranking fifth in the world and holding the top spot in Africa for total count. The primary use of cow dung in India is as a source of fertilizer, and it is also dried to serve as fuel for cooking purposes. With the Indian government's ambitious plan to provide electricity to all citizens by 2025, the rural population of the country will eventually shift towards using electricity for energy, potentially resulting in wasted cow dung. Therefore, it is necessary to explore alternative plans for utilizing this free and valuable resource. Considering that cement is extensively used in building construction in India and is responsible for the highest embodied energy and CO_2 emissions, incorporating cow dung ash as a supplementary cementitious material presents a promising solution for addressing the environmental challenges stemming from both the cement industry and cow dung waste.

Also, as the parcels of cow soil can be affected by multiple factors, the findings of this study are significant and new, as no previous exploration has been carried out on this content in the particular region where the study was conducted.

SCOPE OF THE STUDY

- Examine the effectiveness of using CDA as partial replacement of cement and a study will be conducted on strength parameter.
- The material is locally available and that can also reduce the cost of producing Mortar for construction.
- Necessity of consumption of the waste material for manufacturing of sustainable mortar for construction.
- The cement industry is held responsible for some of the carbon-dioxide emission which contributes the global warming. To overcome these problems, in this project work CDA is used as supplementary cementitious material.

1.3 OBJECTIVE OF THE STUDY

- To investigate the compressive strength of mortar with CDA to that of normal mortar.
- To prepare high strength, eco-friendly and cost effective mortar.
- To evaluate the significance and importance of consumption of the waste material for manufacturing of sustainable mortar for construction.

LITERATURE REVIEW

1.Simango D.G. and Lyson A.A.B. (2005). The development of local construction industry has resulted in the high demand for cement, used not only for structural but also non structural applications, such as finishing. As a consequence cement has been far from being an affordable material for the good part of the population, especially in the rural areas where financial means are still limited. Regarding the finishing exercise, those people have been using soil mortar alone or reinforced with grasses without any strategy about mixture content. The objective of this study was to assess the performance of cohesive soil mortar

mixed with cow dung and establish recommended mix content for plastering works. Twelve samples of soil mortar with 10%, 20%, 30% and 40% of cow dung, were prepared and subjected to drying period of 28 days before they were tested for water absorption, shrinkage, weathering resistance, specific gravity and Atterberg limit tests.

2.Pavan Kumar V S R and Raj Polu 2012 the studies on durability of concrete have attracted attention in the recent years and its long term strength depends on quality of ingredients used in production of concrete. Now days, the availability of ingredients is limited and in order to overcome this problem, research studies focuses on some alternate materials in the concrete production process. Also, Incorporation of waste materials consumes less energy leading to reduction of emission of green house gases. The application of fly ash and cow dung ash as a pozzolanic binder instead of cement and coir fibers finds extensive application in the manufacturing process of building materials.

3.C Venkatasubramanian ,D Muthu, G Aswini, G Nandhini and K Muhilini (2012); The development of local construction industry has resulted in the high demand for cement, used not only for structural but also non structural applications, such as finishing. As a consequence cement has been far from being an affordable material for the good part of the population, especially in the rural areas where financial means are still limited. Regarding the finishing exercise, those people have been using soil mortar alone or reinforced with grasses without any strategy about mixture content. The objective of this study was to assess the performance of cohesive soil mortar mixed with cow dung and establish recommended mix content for plastering works. Twelve samples of soil mortar with 10%, 20%, 30% and 40% of cow dung, were prepared and subjected to drying period of 28 days before they were tested for water absorption, shrinkage, weathering resistance, specific gravity and Atterberg limit tests. The tests showed good results for checked properties with 20% of cow dung.

4.Peter Paa-Kofi Yalley and Dorothy Manu (2013), This research, reports on the investigation into the strength and the durability properties of earth brick stabilised with Cow dung. A local earth was stabilised chemically by Cow dung. A better compressive strength at the dry state and after 10 minutes of immersion in water was obtained with cow dung stabilization at content of 20% by weight of earth. Bricks stabilised with 20% Cow dung contents by weight of earth has a dry and wet compressive strength of 6.64 and 2.27MPa respectively. There is an increased of about 25% in the dry compressive strength of bricks stabilised with 20% cow dung content over that of the plain earth brick without stabilizer The 20% cow dung content resulted in lower migration of water into the brick (i e. lower permeability). Also the abrasive resistance increased with increase in the cow dung content up to 20%.

5.Agarwal Abhijeet R, Dhase Sanket S and Agarwal Kautuk S 2014 , Now a days, the availability of ingredients is limited and in order to overcome this problem, research studies focuses on some alternate materials in the concrete production process. Also, Incorporation of waste materials consumes less energy leading to reduction of emission of green house gases. The application of fly ash and cow dung ash as a pozzolanic binder instead of cement and coir fibers finds extensive application in the manufacturing process of building materials. In this project an attempt has been made to utilize cow dung ash and coconut fiber as a replacement material of cement in the production of concrete. The cement is partially replaced with cow dung

ash by about 2.5, 3 & 3.5 % by weight and with 1% of coconut fiber.

6.Gurjar Inderveer Singh & Bhadouriya Gautam 2015 Out of the total green houses gases emission to the earth atmosphere 7% of it is contributed by global cement industry, due to emissions of poisonous gases like CO2 Cow dung ash is the undigested residue of plant matter which comes from cows gut. In cow dung nitrogen, calcium, carbon, potassium, and phosphorus have a high content of about 10-15 kg cow dung is produce by a cow in a day, which contain about 28% water in fresh state, 34% of cow dung become ash when it is burned. According to a survey of 2012 there are about 51.2 crore cattle in India. Cow dung is mainly used for cooking food as heat source and also used in biogas plants for making electricity.

7.Kumar & Reddy, 2015 searched on cement replacement in concrete by CDA and found that 5%of CDA replacement increases the compressive strength. It observed that the 5% of CDA replace cement in mortar.

8.Pavithra, 2016 reported that dry cow dung is utilized as fuel energy for domestic intention, which generates solid waste ash and observed that cow dung ash in cement concrete is durable as compared to the normal concrete strength.

9.Sruthy, B.; Mathew, G.M.; Krishnan 2017 The consumption of cement in concrete industries has been increasing day by day to fulfill the needs of infrastructure due to growing population, industrialization and urbanization. The production of cement poses environmental problems due to emission of gaseous pollutants. Cow dung is used as fuel for the domestic purpose, which generates solid waste as ash. This paper presents the result on the study for the use of Cow Dung Ash (CDA) as partial replacement of cement in production of concrete. This replacement was designed to study the effects of adding Cow Dung Ash (CDA) in various percentages by weight (6%, 8%, 10%, 12% and 14%) of cement. To strengthen the CDA concrete and making it more durable 0.5% glass fibre is being added,

10.Aman Kumar (2018), Partial Replacement Of Cement 2018 A conventional concrete is a mixture of cement, coarse aggregate and fine aggregate. The cement is a main constitute in concrete which binds the coarse and fine aggregate. Use of cement in concrete industry is increasing day by day due to growing population and industrialization but production of cement leads to environmental problem due to emission of high amount of carbon dioxide and fine aggregate (River sand) obtain from Rivers. Cow dung ash is a by-product which obtained by burning cow dung cakes. Cow dung cakes used as a fuel for domestic purposes whereas Quarry dust is a byproduct of crushing of rocks in crushing plants which can be use as a fine aggregate in a concrete partially or fully. Cow dung ash and Fly ash both posses cementitious properties and can be use as a partial replacement of binder (cement) in concrete. So, this work is carried out to study the effect on the properties of concrete and cement when cement is partially replaced by fly ash and cow dung ash at various percentages (0% fly ash+0% cow dung ash), (10%fly ash+5%Cow dung ash), (20%fly ash+8 cow dung ash), (30% fly ash +10% Cow dung ash) and (40% fly ash +12% cow dung ash).

11.Nawaz, Ali, U.; Hussain2020 Portland cement concrete is fragile in tension and it has numerous negative impacts on the environment. To deal with these issues, both fiber reinforcement and recycled materials can be utilized to manufacture sustainable and ductile concrete. In this study, the synergistic effects of high-performance mineral admixture silica fume and glass fiber reinforcement were investigated on the hardened properties of RC. For this purpose, two concrete mix families, namely, NC and RC were prepared. To understand the benefits of synergistic utilization of glass fiber and silica fume, in both NC and RC, 0.5%

glass fiber was incorporated with three different levels of silica fume.

12.Vinita meena1,*, Dr. Hemant Sood 2021 This review paper presents the influence of cow dung ash as partial replacement o f c e m e n t m a t e r i a l in production of concrete. In this modern era, many new technologies of construction materials are introduced. Growing population, urbanization and industrialization has increased the requirement of cement. The production of cement leads to environmental issues due to emission of gaseous pollutants. The availability of materials with good quality is less and also economically very high. So we need a material which is cheaper as well as eco friendly for the environment like cow dung ash. These materials are partially replaced by cement. Many experiments by different researcher were done to study the effect of adding CDA in various percentages (0%, 5%, 10%, 15%, 20%, 25% and 30%) by the weight of cement. The curing period is of 7, 14 and 28 days respectively for the testing of compressive strength.

13.Basaran, B.; Kalkan, I.; Aksoylu, 2022 The use of marble wastes in concrete mixtures, causing air and water pollution, has been promoted in the academic and practical spheres of the construction industry. Although the effects of various forms (powder, fine, coarse and mixed) of this waste on the concrete compressive strength has been subject to a decent number of studies in the literature, the difficulties in reaching specific conclusions on the effect of each test parameter constitute a major restraint for the proliferation of the use of marble wastes in the concrete industry. Most of these studies are far from underscoring all of the parameters affecting the concrete compressive strength.

14. Duvallet, T.Y.; Jewell, R.B. Recycling 2023 This study investigated the impact of using cow dung ash (CDA) as a partial replacement for ordinary Portland cement (OPC) in mortar. Mortar mixes are prepared by replacing OPC with CDA at varying levels: 5%, 10%, 15%, 20%, 25%, and 30%. The chemical composition of CDA shows that it is composed primarily of SiO_2, Al_2O_3, and Fe_2O_3, with a significant amount of loss of ignition. The workability, hardened properties, and microstructure of CDA-containing mortars are also analyzed. The increasing CDA content in mortar reduces workability and, beyond 5%, it causes high water absorption due to CDA's porous nature and unremoved organic compounds. This impacts the density and compressive strength of the hardened mortar as well as compromising its homogeneous characteristics. When using 5% CDA, the bulk density and compressive strength of the mortar are comparable to those of the control mixes.

MATERIALS

This is three type metrical used-

(i)Cement (ii) Fine Aggregate (iii) Cowdung

CEMENT Cement is a fine gray powder created from raw materials and chemical compounds that professionals use in various types of construction jobs. It's a manufactured ingredient used in concrete. Professionals create cement by mixing raw materials with metals and minerals such as aluminum, iron, calcium and silicon before heating it to high temperatures to form a solid material called clinker. Clinker is then ground into a powder sold as cement to ready-mix concrete companies. Raw materials in cement may include:

Normally 15 types are cement is used in construction work.

I) Ordinary Portland cement (OPC),
II) Portland pozzolana cement (PPC)
III) Rapid-hardening cement
IV) Extra-rapid-hardening cement
V) Quick-setting cement.

Ordinary Portland cement (OPC),are use project works.

Ordinary Portland cement is the most widely used type of cement manufactured and used worldwide. "Portland" is a generic name derived from a type of building stone quarried on the Isle of Portland in Dorset, England. OPC is suitable for most general concrete jobs and mortar or stucco construction projects.The OPC used in this study had a 42.5R grade and was sourced from Ultratech Cement the quality of the cement was assessed as per ASTM C1084. The grading and physical properties were in conformity with the requirements necessitated by standard specifications of ASTM C150/C150M.

Figure no.1 Ordinary Portland cement

Chemical Composition of Cement with Percentage

S.No.	Oxide	Percentage Range
1	Cao	60-67 %
2	Sio_2	17.25 %
3	Al_2o_3	3-8 %
4	Fe_2o_3	.5-6 %
5	Mgo	.1-4 %
6	Na_2o,p_2o_5,k_2o	.4-1.3 %
7	So_3	1.3-3 %

Fine Aggregate Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter. Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and fine **aggregate density** strongly influence the hardened properties of the concrete. The concrete or mortar mixture can be made more durable, stronger and cheaper if you made the selection of fine aggregate on basis of grading zone, particle shape and surface texture, abrasion and skid resistance and absorption and surface moisture.

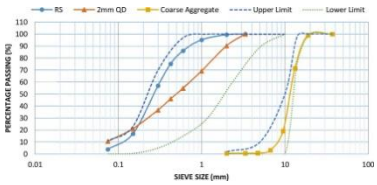


Figure 2. Fine aggregate gradation curve.

Properties of Fine Aggregates - Shape and texture: Size and shape greatly influence the quality of the concrete mix. For the preparation of economical concrete mix, you should know that rough-textured, angular, and elongated particles require more water for the formula. However, you will need less water to produce workable concrete when the aggregates are smooth, rounded compact aggregate.

- Absorption and surface moisture: The fine aggregate density depends on the inside solid material and void content, thus you need to measure the absorption rate prior to ensure how much water will be required in the concrete mixture.
- Abrasion and skid resistance: In order to minimize the wear in high traffic areas, such as heavy duty floors and pavements you can consider the relative measure when the fine aggregate is rotated in a cylinder along with some abrasive charge.

Cow Dung Ash - The cow dung samples were obtained from the cattle production area Cow Shala surrounding the city of Gwalior, India .The samples were sun-dried for a week and subsequently calcined in a muffle furnace at 800 ◦C for 2 h. This particular temperature was chosen as it was found to yield CDA of superior quality. Once burned, the samples were allowed to cool and then ground using a milling machine. Samples that passed through a sieve size of 150 µm were used for cement replacement. The resulting cow dung ash had a dark gray appearance, as shown in

Figure no. 3 Cow dung

Figure no. 4 CDA

Properties of CDA –

(i) It is bulky.

(ii) It has large ash content.

(iii) It has low volatile content after burning

(iv) Carbon content is low.

(v) Economical.

(vi) Eco-friendly material.

(vii) Burning ratio is low.

Advantages of cow dung ash civil engineering -

1.Cow dung is rich with minerals such as potassium, magnesium and phosphorous, which acts as a good binder. It also improves the texture of soil and help it to maintain moisture.

2. The Cow Dung Ash in mortar retards the setting time therefore it can be used as a retarder in mortar in hot weather conditions.

Methods & Results- After conducting multiple tests on the material characteristics of cement, fine summations, and CDA, the plasticity, hardened, and micro structural parcels of the control and CDA-containing mortar samples were assessed using the test styles and types presented in Table 4.These styles cleave toASTM norms. The parcels of hardened mortar correspond of water immersion, bulk viscosity, compressive strength, unity, and resistance to sulfate attack.
To carry out these tests, the mortar composites were moldered into 50 mm 50 mm 50 mm cells. After molding, the cells were covered with plastic wastes and stored at room temperature for 24 h.
The cells were also removed from the molds and submerged in water for curing until the time of the test, which passed at 3, 7, 28, 56, and 91 days. To dissect the micro structural parcels of mortar samples containing CDA, named samples passed thermo gravimetric analysis (TGA) and Fourier transfigure infrared(FTIR) spectroscopy.

Table No. 1

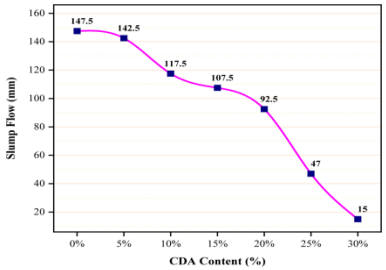
The fresh, hardened, and micro structural properties test results of the mortars.

Test Category	Properties	Test Standards	Examined Samples	Curing Ages
Fresh	Workability	ASTM C1437	All	
Harden ed	Water absorption Bulk density Compression strength Homogeneity Sulfate attack resistance	ASTM C1403 ASTM C642 ASTM C109/C109MASTM C597 ASTM C1012	All	3, 7, 28 and 56 days
Microstruc ture	Thermal decomposition Mineralogical composition	---	CDA0, CDA10, CDA30	7 ,28 days 28 days

Effects of CDA on Workability-The workability or fresh property of the plastic mortar was determined by measuring its consistency using the flow table method in accordance with ASTM C1437. The result of this test is shown in Figure 4.1. As can be observed from this figure, the slump of the mortar decreased significantly with increasing levels of CDA replacement. The greatest reductions in slump were observed for CDA replacement levels of 25% and 30%, with slumps decreasing by 68% and 90%, respectively,

compared to the reference mix (CDA0). Similar findings were reported by. This phenomenon is primarily attributed to the higher porosity of CDA particles in comparison to cement

Figure 5 Slump flow of fresh mortar mixes.



Water Absorption-The water absorption test results are presented in Table 4.1, which reveal that the water absorption of the mortar specimens increased as the percentage of CDA content increased at all curing ages. The increased water absorption can be ascribed to the porous characteristics of CDA particles, as these particles possess a significant capacity to absorb water. This effect becomes particularly pronounced as the content of CDA in the mixture increases.The water absorption of the mortar samples with CDA content beyond 15% exceeded the maximum allowable limit of 10%. It is important to note that lower water absorption is associated with lower porosity percentage and better compressive strength of the mortar paste.

Table 4.1.

Water absorption of the reference and CDA-containing mortar specimens

CDA Content	3rd Day	7th Day	28th Day	56th Day
0%	10.03	9.90	9.74	8.35
5%	10.64	10.54	10.14	9.71
10%	11.05	10.96	10.20	9.75
15%	11.38	11.25	11.12	9.78
20%	11.90	11.49	11.46	11.04
25%	12.15	11.34	11.30	11.22
30%	12.30	12.10	11.80	11.34

Compressive Strength-

Figure 6. illustrates the cube compressive strength of mortar specimens at different curing periods with varying percentages of cow dung ash. It can be observed from Figure 4.2 that there was a linear decrease in the compressive strength of the mortar with an increase in the percentage of CDA used, and the greatest reduction was observed for the specimens containing 30% CDA across all curing periods. The observed reduction in compressive strength is expected, given that the water absorption increased and bulk density decreased with increasing CDA content. The slow rate of strength development can be attributed tothe low CaO content present in CDA.

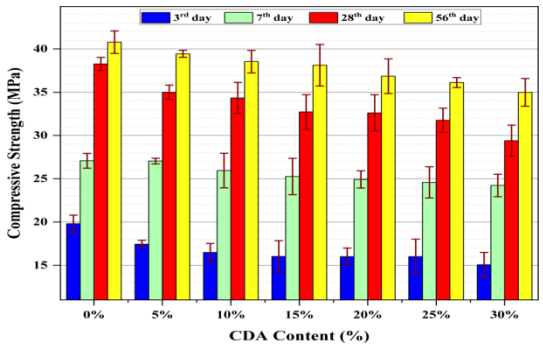


Figure no. 6 The compressive strength of mortar cubes

Even at 15% replacement of cement with CDA, the reduction in compressive strength at the age of 56 days was not found to be significant. In comparison to the control mix sample, it was observed that at a curing time of 28 days, the compressive strength of the mortar specimens containing 20%, 25%, and 30% CDA decreased by 5.66 MPa, 6.51 MPa, and 8.87 MPa, respectively. As per the Indian Standard, IS 2250, the cement and sand mortar should have a minimum compressive strength of 11.5 MPa and 17.5 MPa at the end of 3 and 7 days, respectively. It can be observed that all the mortars containing CDA samples met the specified standards.

CONCLUSIONS

- In this study, we investigated the potential use as an adjunctive cementitious material by examining the physical and chemical properties of cow dung ash (CDA). This study also investigated how different levels (5%, 10%, 15%, 20%, 25%, and 30%) of CDA affect the workability, hardening and micro structural properties of the mortar. Based on the research results, we can draw the following conclusions:
- CDA's oxide composition meets ASTM C150/C150M cement requirements and is very similar to regular Portland cement. However, compared to CDA, OPC contains large amounts of the main oxides CaO and SiO2.
- As the proportion of CDA in the mortar mixture increases, workability decreases. The mortar mixture containing CDA has a reduced slump compared to the control mortar. 15 A mortar meets the slump requirements of ASTM C1437.
- When CDA was employed beyond 5% , the water immersion of the mortar samples vastly increased due to the pervious nature and significant presence of organic composites that weren't effectively removed. As a result, all of the viscosity, unity, and compressive strength of the mortar were negatively impacted. Although the use of CDA as a relief for OPC redounded in a drop in compressive strength, the reduction wasn't considered significant for over to a 15% negotiation, as observed at the age of 56 days.
- Mortar mixes containing 10%, 20%, and 30% CDA were found to exhibit thermal stability when exposed to temperatures ranging from 500◦C to 600 ◦C. The FTIR analysis revealed the presence of unreacted particles and a wide-stretched C–S–H gel in the mortar samples.

REFERENCES

1. Simango D.G. and Lyson A.A.B. (2005). Use of cowdung as a soil stabilizer for construction of Adobe. Malawi Journal of Science and Technology, Vol. 1 pp. 15-20
2. Pavan Kumar V S R and Raj Polu 2012 Incorporation of cow dung ash to mortar and concrete Int. J. Eng. Res. Appl. 2 580-5.
3. C Venkatasubramanian*, D Muthu, G Aswini, G Nandhini and K Muhilini (2012); Experimental studies on effect of cow dung ash (pozzolanic binder) and coconut fiber on strength properties of concrete;
4. Adinkrah-appiah (2013), Improving the Structural Characteristics of Earth. International Journal of Science and Research, pp. 1119-1126.
5. Peter Paa-Kofi Yalley and Dorothy Manu (2013), Strength and Durability Properties of Cow Dung Stabilised Earth Brick; Civil and Environmental Research, Vol.3, No.13, 2013
6. Ojedokun O Y, Adeniran A A, Raheem S B and Aderinto S J 2014 Cow dung ash (CDA) as partial replacement of cementing material in the production of concrete British J. Appl. Sci. Technol. 4 3445-54
7. D.P. Katale, V.S. Kamara and A.A. Adedeji (2014), Investigation on the Use of Clayey Soil Mixed with Cow Dung to Produce Sustainable Bricks; Trends in Applied Sciences Research, Volume 9 (8): 406-424, 2014 IS 2250 (1981): Code of Practice for Preparation and Use of Masonry Mortars Kwadwo Adinkrah-Appiah, Evans
8. Thej Kumar, R. Harshini Reddy and DVS Bhagavanulu (2015), A Study on the Replacement of Cement in Concrete By Using Cow Dung Ash; International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-9, December 2015
9. Gurjar Inderveer Singh and Bhadouriya Gautam 2015 A study on use of Cow-Dung Ash & Ricehusk ash in concrete Int. J. Res. Eng. Technol. 4 101-9
10. Jitender Kumar Dhaka and Roy Surendra 2015 Utilization of fly ash and cowdung ash as partial replacement of cement in concrete Int. J. Civ. Stru. Eng. 6 323-46
11. Sruthy, B.; Mathew, G.M.; Krishnan, A.G.; Raj, S.G. An Experimental Investigation on Strength of Concrete Made with Cow Dung Ash and Glass Fibre. Int. J. Eng. Res. 2017, 6, 492–495.
12. C Venkatasubramanian, D Muthu, G Aswini, G Nandhini and K Muhilini, Experimental studies on effect of cow dung ash (pozzolanic binder) and coconut fiber on strength properties of concrete,IOP Conference Series: Earth and Environmental Science, volume 80, pp 112-120, March 2017.
13. ,Okello Thomas, Prof. Oyawa Walter. Dr. Ajwang Patrick, Use of Cow Dung and Local Brewery Waste as a Partial Replacement of Cement for Plastering Low Cost Houses, IOSR Journal of Mechanical and Civil Engineering, volume 14-Issue 3, pp 27-32, June 2017.
14. Sruthy B, Gibi Miriyam Mathew, Anisha G Krishnan, Sruthi G Raj (2017). An Experimental Investigation on Strength of Concrete Made with Cow Dung Ash and Glass Fibre;
15. Aman Kumar (2018), Partial Replacement Of Cement With Fly Ash And Cow Dung Ash By Using Quarry Dust As A Fine Aggregate; International Journal of Engineering Science Invention (IJESI), Volume 7 Issue 10 Ver II, PP 01-11,2018.

16. Ramachandran, D.; Vishwakarma, V.; Viswanathan, K. Detailed studies of cow dung ash modified concrete exposed in fresh water. J. Build. Eng. 2018, 20, 173–178.
17. Lehne, J.; Preston, F. Making Concrete Change Innovation in Low-Carbon Cement and Concrete; Policy Commons: London, UK, 2018.
18. Rawal, H.M.; Deshmukh, M.; Patil, J. Partial Replacement of Cow Dung with Cement. Int. J. Sci. Res. Eng. Trends 2019, 5, 518–521. Pervious Concrete Tiles with Using Cow Dung, Ash and Coconut Shells for Small Amount Replacement of Cement and Concrete, International Journal of Engineering Science and Computing, volume 9, Issue no.7, pp 23201-23205, July 2019.
19. Dhiraj Thakur, Suraj Thakur, Neeraj Pal, PranavKasbe, Shreeshail Heggond, effect of cow dung on physical properties of concrete, International Research Journal of Engineering and Technology (IRJET), volume: 06 Issue: 03, pp 4470-4472, March 2019.
20. T. Omoniyi, S. Duna, A. Mohammed, Compressive strength Characteristic of Cow Dung ash blended cement Concrete, International Journal of Innovative Technology and Exploring Engineering, volume 9, Issue 2S2, pp 798-802, December 2019.
21. Aishwarya Suresh, Ardra M, Krishnakumar, Muhammed Ashik, Abin Joy, To study the mechanical properties of cow dung ash modified concrete, International Journal of Scientific & Engineering Research, vol 10, pp 126-131, May 2019.
22. Hwang, C.L.; Yehualaw, M.D.; Vo, D.H.; Huynh, T.; Largo, A. Performance evaluation of alkali activated mortar containing high volume of waste brick powder blended with ground granulated blast furnace slag cured at ambient temperature. Constr. Build. Mater. 2019,
23. ASTM C1084-19; Standard Test Method for Portland-Cement Content of Hardened Hydraulic-Cement Concrete. ASTM Interna- tional: West Conshohocken, PA, USA, 2020.
24. Cosentino, I.; Liendo, F.; Arduino, M.; Restuccia, L.; Bensaid, S.; Deorsola, F.; Ferro, G.A. Nano CaCO3 particles in cement mortars towards developing a circular economy in the cement industry. Procedia Struct. Integr. 2020, 26, 155–165.
25. ASTM C117-17; Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing. ASTM International: West Conshohocken, PA, USA, 2020.
26. Azhar, N.S.D.M.; Zainal, F.F.; Abdullah, M.M.A.B. Effect of Geopolymer Paste on Compressive Strength, Water Absorption and Porosity; AIP Publishing LLC: 2020.
27. Pappis, I.; Sahlberg, A.; Walle, T.; Broad, O.; Eludoyin, E.; Howells, M.; Usher, W. Influence of Electrification Pathways in the Electricity Sector of Ethiopia—Policy Implications Linking Spatial Electrification Analysis and Medium to Long-Term Energy Planning. Energies 2021, 14, 1209.
28. Global Cement and Concrete Association (GCCA). Global Cement and Concrete Industry Announces Roadmap to Achieve Groundbreak- ing 'Net Zero' CO2 Emissions by 2050; Global Cement and Concrete Association (GCCA): London, UK, 2021.
29. Ige, J.A.; Olojo, F.O. Effect of Cow Dung Ash Calcined at Different Temperature on the Geotechnical Properties of Laterite Soil. J. Archit. Civ. Eng. 2021, 6, 38–47.
30. Ekasila, S.; Vishali, B.; Anisuddin, S. An experimental investigation on compressive strength of concrete

with rice husk and cow dunk ash using various curing methods. Mater. Today Proc. 2022, 52, 1182–1188.

31. Beskopylny, A.N.; Shcherban', E.M.; Stel'makh, S.A.; Meskhi, B.; Shilov, A.A.; Varavka, V.; Evtushenko, A.; Özkılıç, Y.O.; Aksoylu, C.; Karalar, M. Composition Component Influence on Concrete Properties with the Additive of Rubber Tree Seed Shells. Appl. Sci. 2022, 12, 11744.
32. ASTM C150/C150M-22; Standard Specification for Portland Cement. ASTM International: West Conshohocken, PA, USA, 2022. Endale, S.A.; Taffese, W.Z.; Vo, D.-H.; Yehualaw, M.D. Rice Husk Ash in Concrete. Sustainability 2022, 15, 137.
33. Zeybek, Ö.; Özkılıç, Y.O.; Karalar, M.; Çelik, A.I˙.; Qaidi, S.; Ahmad, J.; Burduhos-Nergis, D.D.; Burduhos-Nergis, D.P. Influence of Replacing Cement with Waste Glass on Mechanical Properties of Concrete. Materials 2022, 15, 7513.
34. Basaran, B.; Kalkan, I.; Aksoylu, C.; Özkılıç, Y.O.; Sabri, M.M.S. Effects of Waste Powder, Fine and Coarse Marble Aggregates on Concrete Compressive Strength. Sustainability 2022, 14, 14388.
35. Yehualaw, M.D.; Alemu, M.; Hailemariam, B.Z.; Vo, D.-H.; Taffese, W.Z. Aquatic Weed for Concrete Sustainability. Sustainability
2022, 14, 15501.
36. Gedefaw, A.; Worku Yifru, B.; Endale, S.A.; Habtegebreal, B.T.; Yehualaw, M.D. Experimental Investigation on the Effects of Coffee Husk Ash as Partial Replacement of Cement on Concrete Properties. Adv. Mater. Sci. Eng. 2022, 2022, 4175460.
37. Shcherban', E.M.; Stel'makh, S.A.; Beskopylny, A.N.; Mailyan, L.R.; Meskhi, B.; Shilov, A.A.; Chernil'nik, A.; Özkılıç, Y.O.; Aksoylu, C. Normal-Weight Concrete with Improved Stress–Strain Characteristics Reinforced with Dispersed Coconut Fibers. Appl. Sci. 2022, 12, 11734.
38. Duvallet, T.Y.; Jewell, R.B. Recycling of bone ash from animal wastes and by-products in the production of novel cements. J. Am. Ceram. Soc. 2023, 106, 3720–3735.
39. ASTM C1585-20; Standard Test Method for Measurement of Rate of Absorption of Water by Hydraulic-Cement Concretes. ASTM International: West Conshohocken, PA, USA, 2020.
40. IS 2250; Code of Practice for Preparation and Use of Masonry Mortars. Bureau of Indian Standards: Delhi, India, 1981.
41. IS 13311 (Part 1); Method of Non-Destructive Testing of Concrete, Part 1: Ultrasonic Pulse Velocity. Bureau of Indian Standards: Delhi, India, 1992.