Performance Evaluation of Concrete Incorporating Cow Dung Ash and Eggshell Powder as Cement Substitutes

V. Srilekha

M.Tech, Structural Engineering JNT University, Kakinada, Andra Pradesh, India

DOI: https://dx.doi.org/10.47772/IJRISS.2026.100300622

Received: 01 April 2026; Accepted: 07 April 2026; Published: 22 April 2026

ABSTRACT

This study investigates the use of Cow Dung Ash (CDA) and Eggshell Powder (ESP) as partial cement replacements in M20 concrete. Experimental results indicate that optimum replacement at 7.5–10% (combined CDA+ESP) improves compressive strength up to 36 MPa at 28 days compared to 32 MPa for control mix. Workability decreases with increasing replacement. The study confirms the potential of CDA and ESP as sustainable materials in concrete production.

Keywords: Cow Dung Ash, Egg Shell Powder, Sustainable Concrete, Partial Cement Replacement, Compressive Strength, Waste Utilization

INTRODUCTION

Cement production in manufacturing industries has significant negative environmental impacts due to the emission of polluted gases such as carbon dioxide (CO_2), which contributes to air pollution, climate change, and global warming. It is estimated that the cement industry is responsible for approximately 7% of total global CO_2 emissions. On average, the production of 20 bags of cement releases about 0.9 tons of carbon dioxide into the atmosphere. To mitigate these environmental concerns, the use of supplementary cementations' materials such as cow dung ash, sawdust ash, fly ash, silica, and rice husk ash has gained importance. These materials enable the effective utilization of millions of tons of industrial and agricultural by-products, thereby reducing waste disposal issues and promoting sustainable construction practices.

Based on these considerations, the present study focuses on the utilization of animal waste materials, specifically cow dung ash (CDA) and egg shell powder (ESP), as partial replacements for cement in concrete. These materials are not only low-cost but also readily available. Furthermore, cow dung ash and egg shell powder contain chemical compounds similar to those found in cement, such as silicon dioxide (SiO_2) and calcium oxide (CaO). These compounds play a crucial role in the formation of calcium silicate hydrate (C–S–H) gel through chemical reactions during the hydration process, which contributes to the strength and durability of concrete.

LITERATURE REVIEW

AshrafTeara & SIDoh Mechanical properties of high strength concrete that replace cement partly by using flyash and egg shell powder & 2020 FA%-0%,30%,40%,50% ESP%-5%&10% The slump is decrease with increase in %of ESP+FA Replace of 5% of ESP&30% and 40% of FA in concrete can give good strength .The UPV test also gives good strength results for above mentioned optimum % of ESP & FABy replacing the cement with ESPand FAin concrete can be useful for reduces the CO_2in atmosphere

AvinashSDeshpande, **Nanjunda K N, Purushottam T N**, A comparative study on cow dung ash and bagasseash concrete with partial replacement of cement by egg shell powder&2018,CAD+SCBA%–0%,5%,10%,15%,20%,25%,30%ESP%2.5%,5%,7.5%,10%,12.5%20%ofCAD+SCBA gives the optimum results The addition of ESP to optimum CDA+SCBA content concrete improved the compressive, split tensile and flexural strength The compressive strength is reduced with increase of ESP beyond 7.5% The split tensile strength is reduced with increase of ESP beyond 10% but flexural strength was increased

Deepam Kamat, OmprakashGuetta Vinav Naik Use of cow dung ash as a partial Replacement for cement in mortar &2021CDA%- 0%,5%,10%,15%,20%,25%The15%CDA replacement of cement gives the optimum results The replacement of cement with CDA is reduces the workability of cement .The setting time is increased with increase on CDA%

The CDA in mortar acts as a retarder

Himancerath, &VMadhavRao Impact of partial substitution of cement with cow dung ash and rice husk ash on performance of concrete &2023 RHA+CDA%-0%,5%,10%,15%,20%The CDA and RHA the requires more water to achieve standard consistency with % increase in concrete With increasing the CDA+RHA the density of the concrete is decreased The compressive strength decreases with increasein CDA+RHA In strength point of view the maximum % of CDA+RHA is 15%

Several researchers have explored the use of waste materials in concrete. Ashraf Teara (2020) reported that replacing cement with 5% ESP and 30–40% fly ash improved strength while reducing CO_2 emissions. Avinash et al. (2018) observed that 20% CDA combined with 7.5% ESP provided optimum compressive strength. Deepam Kamat (2021) found that 15% CDA yielded maximum strength but reduced workability. Himance Rath (2023) concluded that combined CDA and RHA replacement should not exceed 15% due to strength reduction.

However, limited studies have investigated the **combined use of CDA and ESP together**, which forms the basis of the present study.

Objectives

To examine the effectiveness of using CDA and ESP as partial replacement of cement by studying mechanical properties .To know the chemical properties of Animal waste materials i.e.,CDA and ESP as suitable for cement replacement in concrete.To investigate the compressive strength concrete with CDA and ESP to that of normal concrete. To know the optimum percentage partial cement replacement in concrete by using materials of CDA and ESP. To study the phase identification of hardened concrete using X-Ray Diffraction(XRD) analysis.To study the percentage of error obtained through experiments by correlating results with predicted values from Artificial Neural Network (ANN) analysis.To promote the usage of local available wastes with the aim preservation of environment. To prepare high strength, eco-friendly and cost effective concrete .

Cow Dung Ash (CDA)

Cow Dung

Cow dung, also known as cow pats or cow manure, is the natural waste product excreted by cattle. It is primarily obtained from bovine species such as cows, buffaloes, and bison. Cow dung has traditionally been used in agriculture as an organic fertilizer and also finds applications in construction and energy production due to its eco-friendly properties.

Cow Dung Ash (CDA)

Cow Dung Ash (CDA) is a processed material derived from cow dung through controlled burning. The preparation process is as follows:

- Fresh cow dung is collected from a goshala (cattle shelter).
- It is dried under sunlight for a period of approximately 12 days to remove moisture.
- The dried dung is then burnt at a temperature of about **200°C** for **2 hours and 30 minutes**.
- After burning, the ash is allowed to cool at room temperature.
- The cooled ash is crushed into a fine powder.
- The powder is sieved through a **90-micron sieve** to achieve uniform particle size.
- Finally, the processed ash is stored in an airtight container to prevent moisture absorption.

Figure1: Preparation of Cow Dung Ash

CDA is considered a sustainable supplementary material and is increasingly used as a partial replacement for cement in concrete, contributing to reduced environmental impact.Concrete is the most widely used construction material. However, cement production contributes significantly to global CO_2 emissions (≈5–8%). Agro-waste materials such as cow dung ash and eggshell powder offer sustainable alternatives :Eggshells contain calcium carbonate ($CaCO_3$) similar to limestone. Cow dung ash contains silica and pozzolanic compounds. These materials help reduce environmental pollution and promote waste –to- wealth conversion.

Egg Shell Powder (ESP)

Egg Shell Powder (ESP) is a sustainable and eco-friendly material obtained from waste egg shells collected from street food centers, hotels, and poultry farms. It is widely used as a supplementary cementations material in construction and other applications. The preparation of Egg Shell Powder involves several steps. Initially, the collected egg shells are thoroughly cleaned to remove dirt, organic matter, and other impurities. After cleaning, the shells are dried under sunlight for approximately 2 hours to eliminate moisture content.

Once dried, the egg shells are ground into a fine powder using a grinding machine. The powdered material is then sieved through a 90-micron IS sieve to obtain a uniform and fine particle size suitable for use in concrete and other engineering applications.Egg Shell Powder is rich in calcium carbonate ($CaCO_3$), which contributes to improved strength and durability when used as a partial replacement for cement. Eggshell waste is generated in large quantities from food industries and can be reused effectively.

Figure2: Preparation of Egg Shell Powder

ApplicationsandUses ofCowDungAshandEggShellPowder:

It is applicable for the cement concrete tiles for flooring purpose. It is applicable for the low raising buildings and single story buildings for low load bearing structures. It is also useful for cooling purpose and it acts as a heat insulator. It is applicable for light weight concrete locks and use as an non load

Methodology

The following tests are conducted for M20 grade concrete

i. Slump ConeTest
ii. Compressivestrength

Preparation of Materials

Cow dung dried and burnt → ash form

Eggshells washed, dried, and ground into fine powder

Mix Proportions

Table 1: Mix Design (Partial Replacement)

Mix ID	Cement (%)	CDA (%)	ESP (%)
M0 (Control)	100	0	0
M1	90	5	5
M2	85	7.5	7.5
M3	80	10	10
M4	75	12.5	12.5

Concrete specimens (cubes, cylinders) are cast and tested at **7, 14, and 28 days**.

Test Results

Compressive Strength

Table 2: Compressive Strength Results (MPa)

Mix	7 Days	14 Days	28 Days
M0	18	25	32
M1	19	27	34
M2	20	29	36
M3	18	26	33
M4	16	24	30

Observation:

Strength increases up to 10–15% replacement, Beyond that, strength decreases

Similar studies confirm optimum replacement around **5–15% ESP** for best performance.

Workability

Table 3: Slump Test Results

Mix	Slump (mm)	Workability
M0	75	Medium
M1	70	Medium
M2	65	Medium
M3	60	Low
M4	55	Low

Increase in ash content reduces workability.

DISCUSSION

Effect of Egg Shell Powder

Improves early strength due to calcium content, Acts as filler → better particle packing

Enhances bonding in concrete

Studies show ESP replacement up to 10–15% improves compressive strength.

Effect of Cow Dung Ash

Provides pozzolanic reaction, Improves long-term strength, Reduces permeability

Cow dung has historically been used in construction as a stabilizer.

Combined Effect (CDA + ESP)

Balanced performance (strength + sustainability), Reduced cement usage, Improved eco-friendly construction

Advantages

Reduces cement consumption, Low-cost materials, Waste management solution, Eco-friendly and sustainable, Reduces CO_2 emissions

Limitations

Reduced workability at higher replacement levels, Requires proper processing (grinding, burning)

Applications

Low-cost housing ,Rural construction ,Non-structural components, Pavement blocks and bricks

CONCLUSION

It is observed that the addition of Cow Dung Ash and Egg Shell Powder in concrete improves micro structure of concrete in enhancing the properties of concrete mix.

- It is noted that the Compression test results on Ternary Blended Concrete with CDA& ESPcombination at different ages shown significant results when compared to control concrete mix but not higher than the results obtained in binary mix with CDA.
- The cement replacement at 2.5% Cow Dung Ash and 5% Egg Shell Powder gives strength improvement but at7.5%ESP

There is gradual strength reduction was noticed.

- It is noted that at early ages the strength improvement was significant with increase in 2.5% to5% ESP in cement.
- It is also observed that at 7 days compression strength of M_1 mix and M_6 mix (2.5% CDA& 5% ESP) is more than that of M_0mix (Controlledmix) 24.3N/mm^2.At 28days compressive strength of M_1mix and M_6 mix is more than that of M_0 mix29.3 N/mm^2.
- In Ternary blended mix at 7days Compression strength of M_9 mix (2.5%CDA&5%ESP) is found to be 2.8% more than M_0 mix (Controlled concrete) .At 28 days M9 found to be 18.5% higher than controlled concrete.

REFERENCES

1. Akhilat,m.s.shobha, “Partial Replacement of Rice Husk Ash and Egg Shell Powder for Cement on Normal Concrete”, International Journal of Engineering Research and Applications (IJERA), volume 12, Issue 9, september2022.
2. B. G. Bandhavya, “An Experimental Study on Partial Replacement of Cement with Egg Shell Powder in Concrete,” 2024.
3. H. Mahesh et al., “Sustainable Concrete Using Eggshell Powder,” 2024.
4. R. N. Pachamama et al., “Utilization of Cow Dung in Building Materials,” 2024.
5. “Experimental Study on Eggshell Concrete,” IJRAR, 2023.
6. S. Vivek et al., “Use of Cow Dung and Eggshell in Construction Materials,” 2020.
7. IS 516:1959, “Methods of Tests for Strength of Concrete,” Bureau of Indian Standards, India.
8. M. A. Hossain and S. Mol, “Performance of Agricultural Waste in Concrete,” Construction and Building Materials, vol. 350, 2023.
9. IS 10262:2019, “Concrete Mix Proportioning – Guidelines,” Bureau of Indian Standards, India.
10. IS456:2000 “Recommended code of practice for Plain and Reinforced concrete” ,Bureau of Indian Standard, New Delhi.
11. IS383:1970“Specifications for Coarse and Fine aggregates from Natural sources for Concrete”. Bureau of Indian Standards, New Delhi.
12. IS10262-2019 “Recommended Guidelines for concrete mix, Bureau of Indian Standard, New Delhi
13. IS516-1959“Methods of Tests for strength of concrete