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Eco-Friendly Concrete: Investigating the Mechanical Properties of M20 Concrete with Alternative Cementitious Materials

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ABSTRACT: The growing need for cement in the building sector calls for investigation of substitute materials to somewhat replace it. This work examines partial replacements of cement in M20 grade concrete between cow dung ash (CDA) and rice husk ash (RHA). Maintaining a water-cement ratio of 0.5, concrete cubes (150x150x150 mm) were tested by substituting CDA and RHA at 5%, 10%, and 15% quantities from cement. The concrete mixes were let to cure for seven, fourteen, and twenty-eight days. Because CDA and RHA are pozzolanic, the data show that the compressive strength first improves up to 10-15% replacement. Strength falls, nevertheless, beyond this range. RHA turned out better than CDA among the two materials. This study emphasises the viability of using CDA and RHA as additional cementitious materials, therefore maximising their use in environmentally friendly building.

KEYWORDS: Concrete cube, CDA, RHA, Compressive strength, M20 grade concrete.

I. INTRODUCTION

Modern building depends mostly on concrete as it is flexible, strong, and long-lasting. Infrastructure, homes, bridges, and roads all have it used extensively. But especially CO2 emissions, the large manufacturing of cement, the main binding agent in concrete, greatly adds to environmental damage. The growing need for environmentally friendly building materials has driven scientists to look at other materials that may partially replace cement without compromising the structural integrity of concrete. One approach would be to partially replace cement with agricultural waste products such RHA and CDA. These pozzolanic materials show their reactivity with calcium hydroxide in cement to produce additional binding compounds, hence improving the strength and durability of concrete (Raghav, et al. 2021). Whereas RHA comes from the burning of rice husks, which are common in agricultural areas, CDA comes from the combustion of cow dung, a readily available bio-waste. By means of the recycling of agricultural wastes, both resources help to decrease the ecological impact of cement manufacture and support waste management. The primary goal of this work is to investigate how compressive strength of M20 grade concrete is pretentious by CDA and RHA. The efficiency of concrete cubes with partial cement replacement utilising CDA and RHA at values of 5%, 10%, and 15% is evaluated in this work. To track their strength development over time, the concrete samples are cured for seven, fourteen, and 28 days. The purpose of this effort is to find the optimal level of cement substitution that maintains workability and durability while nevertheless increasing concrete's compressive strength. The relevance of this work is on its ability to progress methods of sustainable building. Using CDA and RHA in concrete cuts dependency on conventional cement, therefore dropping CO2 emissions and promoting more affordable building. Using these waste products follows ideas of resource economics and the circular economy. Engineers, builders, and legislators using alternative cementitious materials for sustainable and ecologically friendly building solutions will find great value in this study. Hence the objective of this work is to assess if partial substitution for cement in M20 grade concrete CDA and RHA is feasible. It focusses on evaluating concrete's compressive strength using varying CDA and RHA substitution ratios for cement. Furthermore, the research aims to evaluate the efficiency of both materials as sustainable substitutes in building by means of their performance in strengthening and durability of concrete.





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II. LITERATURE REVIEW

Scientists and researchers have certainly zoomed in on alternative materials like RHA and dung CDA because of their ability to make concrete better while also making the concrete super sustainable. Those new materials are really attractive for more reasons than one. Although less studied than other SCMs, CDA possesses silica concentration that results in pozzolanic properties that help to manufacture calcium silicate hydrate (C-S-H) gel following contact with calcium hydroxide in cement. Optimising CDA usage depends on further research as its chemical composition and physical properties vary depending on combustion conditions. Studies highlight the importance of proper characterisation in order to enable effective cement replacement without compromising concrete durability. By contrast, RHA has been investigated closely as a cementitious material with major contributions to concrete strength and durability (Chaudhary & Singh, 2018; Krishna et al., 2016). Its high amorphous silica concentration makes it an efficient pozzolan, thereby improving compressive strength (Depaa et al., 2021), tensile strength (Mukilan et al., 2020), and general concrete durability (Habeb & Mahmud, 2010). RHA's pozzolanic reaction lowers porosity and improves pore structure, therefore contributing to a denser concrete matrix. Still, RHA's impact on workability should be taken into account as it usually lowers slump and raises water consumption (Krishna et al., 2016). Balancing workability issues with strength increases depends on optimising the replacement percentage (Chaudhary & Singh, 2018). The combined usage of CDA and RHA in M20 concrete still begs some interesting questions. Studies on the synergistic effects of these minerals are few, even when study has looked at their separate advantages. Research already in publication on mixing RHA with other SCMs, including fly ash, points to possible compressive strength (Sathawane et al., 2013) enhancement. But CDA's special qualities and how it interacts with RHA in concrete mixes call for careful review. A proper mix design guarantees workability and durability and helps to get the required compressive strength. To improve sustainability and structural performance in M20 concrete, further study is required to define ideal replacement values of CDA and RHA.

III. MATERIAL AND METHODOLOGY

M20 grade concrete was utilised for this investigation using Ordinary Portland Cement (OPC), fine cumulative (sand passing a 4.75mm, IS sieve), rough total (20mm size), potable water, and additional materials—CDA and RHA—as partial substitutes for cement. Using a 1:1.5:3 ratio, the concrete mix was made to preserve a 0.5 water-cement ratio. For each percentage replacement, a total of 18 concrete cubes (150x150x150 mm) were produced—nine including CDA and nine with RHA at 5%, 10%, and 15%.



Fig: 3.2. Rice Husk Ash



With cow dung ash (CDA) substituting cement at 5%, 10%, and 15% by weight, a concrete mix will be ready using 12 kilogramme cement, 18 kg sand, 36 kg aggregate, and 12 kg water. Three layers will be poured concrete into the cube moulds. Tamping with a tamping rod 25 times will appropriately compact each layer to guarantee homogeneous density and remove air spaces.





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Fig: 3.3. Cow Dung Ash Fig: 3.4. Compression Testing Machine



The cubes were allowed to set after they were formed and then submerged in a curing tank containing ordinary water for seven, fourteen, and twenty-eight days (Katuwal, 2019). Following their curing time, the cubes underwent compressive strength testing using a Compression Testing Machine (CTM). To guarantee appropriate alignment, the cubes remained taken out of the water tank, cleaned, then put in the machine. Up until the cube collapsed, a slow load of 140 kg/cm² per minute was applied. The compressive strength then was computed using the formula:

 $ext{Compressive Strength} = rac{ ext{Load}(ext{N})}{ ext{Cross-sectional Area}(mm^2)}$

For every curing period—7, 14, and 28 days—observations were taken; the findings were examined and graphically shown to show how CDA and RHA affected the compressive strength of M20 grade concrete. This technique's methodical approach guaranteed accuracy in determining whether CDA and RHA may be used partially in lieu of cement in concrete manufacture. Compressive strength was tested using a CTM as per IS 516:1959 (Bureau of Indian Standards, 1959).

IV. RESULTS AND DISCUSSION

Analysed at varying curing times (7, 14, and 28 days) was the compressive strength of M20 grade concrete with fractional substitution of cement by CDA and RHA. The experimental outcomes show that the force characteristics of concrete change with CDA and RHA inclusion; proportion of replacement influences the changes in these qualities.

rable. 4.1 Compressive Strength rest Results				
	REPLACEMENT %	7 DAYS (MPA)	14 DAYS (MPA)	28 DAYS MPA)
COW DUNG ASH (CDA)	CDA 5%	18.8	22.8	30
	CDA 10%	19.3	24.3	31.9
	CDA 15%	20.6	26.5	33.4
RICE HUSK ASH (RHA)	RHA 5%	19.8	24.4	31.5
	RHA 10%	21.1	26.3	33.2
	RHA 15%	22.3	28	35
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Table: 4.1 Compressive Strength Test Results





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The compressive strength values for CDA exhibited an early rise with 5% and 10% replacement, then peaked at 15% replacement, when the 28-day strength was recorded to be 33.4 MPa. With strength rising gradually with replacement up to 15%, RHA also showed a similar pattern, reaching a maximum compressive strength of 35.0 MPa after 28 days. Given their pozzolanic characteristics, which facilitate the hydration process and bond formation within the concrete matrix, this implies that both CDA and RHA help to increase strength. At all curing ages, RHA has somewhat greater strength performance than CDA, according a comparison of CDA and RHA substitutes. RHA's high silica content, which improves the secondary hydration process and produces a denser and stronger concrete mix, is probably responsible for this. Higher replacement levels above 15%, however, run the danger of lower workability and strength, suggesting the ideal replacement value. The research shows generally that partial substitution of cement with CDA and RHA is feasible to increase the sustainability of concrete while preserving structural integrity. The findings confirm the possible use of these agro-waste materials in building, hence lessening dependence on traditional cement and therefore less environmental effect.

V. CONCLUSION

This work examined the compressive strength of M20 grade concrete using RHA and (CDA as partial replacement of cement at different percentages (5%, 10%, and 15%). Thanks to their pozzolanic characteristics, the findings show that both CDA and RHA help concrete to build its strength. First rising with partial replacement, the compressive strength fell beyond 10–15% replacement. RHA showed more pozzolanic activity than CDA in improving compressive strength among the two materials. Still, too much replacement resulted in lower strength, which emphasises the importance of an ideal proportion. The results point to an environmentally benign substitute for traditional cement that may be efficiently employed up to 10% substitution without appreciably sacrificing concrete strength. Long-term durability, water absorption, and microstructural analysis should be the main areas of emphasis in further studies to prove CDA and RHA as environmentally building materials.

RECOMMENDATIONS

- Further research on durability properties of CDA and RHA concrete.
- Field applications to assess real-world performance.
- Investigation into optimized curing techniques for CDA and RHA concrete.

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