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EXPERIMENTAL INVESTIGATION OF SUSTAINABLE CONCRETE INCORPORATING COW DUNG ASH AND COIR FIBRE

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Abstract: The durability and long-term performance of concrete are significantly influenced by the quality and availability of its constituent materials. In recent years, the depletion of natural resources and the environmental impact associated with conventional cement production have driven research toward sustainable alternatives. This study investigates the feasibility of using cow dung ash (CDA) as a partial replacement for cement and coir fibre (CF) as a reinforcing additive in concrete. Cement was partially replaced with CDA at proportions of 4%, 8%, and 12% by weight, along with the incorporation of 0.5% coir fibre using M30 grade and PPC cement. The mechanical properties of the concrete were evaluated through compressive and tensile strength tests at curing periods of 7 and 28 days. The results indicate a significant improvement in strength characteristics, with an increase of % of CDA compared to conventional concrete.

The findings demonstrate that the use of CDA and coir fibre not only enhances the mechanical performance of concrete but also offers a cost-effective and environmentally sustainable solution. This approach contributes to waste utilization, reduction in greenhouse gas emissions, and conservation of natural resources, thereby supporting sustainable construction practices.

Keywords- Cement, Fine Aggregate, Coarse Aggregate, Cow Dung Ash(CDA), Coir Fibre, Concrete, Compressive Strength, Tensile Strength.

I.INTRODUCTION

The cementing material has been used since the earliest days of engineering construction. The cement industries a major contributor to climate change. Concrete is one of the most widely used materials in the world and second only to water. Around 30 billion tons of concrete are used very year. It is widely used so much because its high compressive strength, durability and has good mechanical properties compared to other construction materials. Its mostly used for construction of strong, long lasting and reliable infrastructure like dams, bridges, roads and other structures. Concrete is also very popular in architecture because it is very flexible to use and it allow the designer to create unique, modern, and innovative designs. We can also transfer it into aesthetically appealing material in design projects.

Cement while indispensable to modern construction, but it is the most environmentally detrimental material. its manufacturing process is highly energy intensive and result in the substantial emission of greenhouse gases, particularly carbon dioxide (CO_2), which significantly contributes to global climate change. In addition to CO_2, cement production releases a range of atmospheric pollutants, including nitrogen oxides (NO_2), and Sulphur dioxide (SO_2), which are known to cause acid rain and Respiratory issues. Cement production alone causes approximatetly7% of global CO_2.

II.LITERATURE REVIEW

Venkatasubramanian et al. (2017) studies on effect of cow dung ash as pozzolanic binder and coconut fiber on strength properties of concrete. Cement was partially replaced with cow dung ash (CDA) at replacement levels of 2.5%, 3%, and 3.5% by weight, while coconut fiber was incorporated at a constant dosage of 1%. The mechanical properties of concrete, specifically compressive strength and tensile strength, were evaluated at different curing ages of 7, 14, and 28 days. The study indicates that the incorporation of cow dung ash (CDA) and coir fiber (CF) results in a significant improvement in the strength properties of concrete, with an increase in the range of approximately 55–70% compared to conventional mixes. Furthermore, the partial replacement of cement with CDA and the addition of CF offer an economical alternative by reducing material costs. The utilization of these materials also contributes to sustainable waste management by minimizing landfill disposal, thereby reducing environmental impact and supporting ecological balance.

Mathew et al. (2017) conducted an experimental analysis of strength properties of concrete with partial replacement of cement by cow dung ash and inclusion of glass fiber as a reinforced concrete. This study was designed to evaluate the effect of incorporating Cow Dung Ash (CDA) as a partial replacement of cement at varying levels of 6%, 8%, 10%, 12%, and 14% by weight. To enhance the strength and durability of CDA-based concrete, glass fiber was added at a constant dosage of 0.5%. The inclusion of glass fiber is intended to improve flexural strength, crack resistance, and overall performance of the concrete. Additionally, the use of CDA and glass fiber presents an economical and sustainable alternative for concrete construction. The M25 grade concrete mix was designed in accordance with standard mix design procedures.
Experimental results indicate that partial replacement of cement with cow dung ash (CDA) up to 8% by weight leads to an enhancement in compressive strength. Furthermore, the study utilized manufactured sand (M-sand) conforming to Zone I grading as the fine aggregate, ensuring adequate particle size distribution and improved concrete performance.

Zerdi et al. (2016) performed an experimental study to assess the feasibility of incorporating cow dung and sawdust as partial replacement materials in concrete, with the dual objective of cost reduction and environmental sustainability. The investigation was conducted on M15 grade concrete, wherein cow dung was used as a partial replacement for cement and sawdust as a partial replacement for fine aggregate. Replacement levels of 0%, 2%, 4%, and 6% were adopted, and the concrete mixes were proportioned with a constant water–cement ratio of 0.65.
The experimental program primarily focused on evaluating the compressive strength characteristics of concrete specimens at curing ages of 3, 7, 14, and 28 days. The results demonstrated a progressive decline in compressive strength with increasing percentages of cow dung and sawdust replacement. At a 2% replacement level, the compressive strength values were found to be comparable to the minimum requirements for lightweight concrete; however, further increases in replacement levels led to a significant reduction in strength, indicating limited suitability of higher replacement proportions for structural applications.

Khandeshwar et al. (2019) investigated the use of cow dung ash (CDA) as a supplementary cementitious material (SCM) to reduce cement consumption and environmental impact. CDA was produced by controlled burning of dried cow dung and exhibited high silica content (~75.5%), confirming its pozzolanic nature. Cement was partially replaced with CDA at levels ranging from 0% to 31% by weight. Physical and chemical properties such as fineness, specific gravity, and setting characteristics were evaluated. Compressive strength tests at 3, 7, 14, and 28 days showed that 6% CDA replacement achieved optimum strength. Beyond this level, strength decreased due to dilution of cement content. Additionally, CDA increased workability, setting time, and water demand, indicating its retarding effect in concrete.

Rayaprolu and Raju (2012) evaluated the feasibility of utilizing cow dung ash (CDA) as a supplementary cementitious material in mortar and concrete to promote sustainable construction. CDA was produced through sun-drying followed by controlled burning and used as a partial replacement of cement at 10%, 20%, and 30% by weight. The study assessed compressive strength at curing ages of 7, 14, and 28 days, along with fresh properties such as consistency, setting time, and workability. Results indicated that compressive strength decreased with increasing CDA content, with optimum performance observed at 10% replacement. Higher replacement levels resulted in significant strength reduction due to dilution of cementitious constituents. Additionally, CDA increased water demand, setting time, and workability, indicating retarding characteristics. The study concluded that CDA is suitable for low-strength or non-structural applications, while its use in structural concrete is limited without further modification.

Kamat et al. (2021) investigated the feasibility of using cow dung ash (CDA) as a partial cement replacement in mortar for sustainable and cost-effective construction. CDA was produced by drying raw cow dung, followed by controlled burning at 420–550 °C, and subsequent crushing and sieving through a 400-micron sieve. Cement was replaced with CDA at levels of 0% to 25% by weight, and compressive strength was evaluated at 7, 28, and 56 days. Results indicated that all mixes satisfied the minimum strength requirements as per IS 4031-6 (1988). The optimum replacement level was found to be approximately 15%, achieving higher long-term strength at 56 days. CDA incorporation increased setting time and reduced workability, indicating retarding behavior. The study concluded that CDA is suitable for mortar applications, though limited to strength evaluation without durability or concrete-level analysis**.**

Sathyakumar et al. (2025) investigated the use of cow dung powder (CDP) as a partial replacement of cement in M20 grade concrete at replacement levels of 5%–20% with a constant water–cement ratio of 0.5. Compressive strength results indicated that 5% CDP achieved optimum strength (27.35 N/mm² at 28 days), exceeding the control mix, while higher replacements reduced strength due to increased porosity and hindered hydration. Water absorption tests showed a significant increase with higher CDP content, indicating reduced durability. The study concluded that 5% CDP is the optimum level for achieving a balance between strength and durability.

III.MATERIAL USED

Cement: Portland Pozzolana Cement (PPC), conforming to the specifications of IS 1489 (Part 1)–1991, was utilized throughout the experimental investigation. The cement was grey in color and exhibited satisfactory fineness and standard consistency in accordance with IS coal provisions. It was stored in airtight containers to prevent moisture ingress and to maintain its physical and chemical properties. The Table-1: shows the physical properties of cement.

Sr. No.	Physical properties	Values	Values as per IS code
1.	Specific Gravity	3.00	2.90-3.10
2.	Initial Setting Time	60 minutes	≥ 30 minutes
3.	Final Setting Time	330 minutes	≤ 600 minutes
4.	Soundness (Le-Chatelier)	0.8 mm	≤10 mm
5.	Standard Consistency	31.5%	28% - 34%

6.	Fineness (Blaine's Surface Area)	332 m^2/Kg	≥ 300 m^2/Kg
7.	Bulk Density	1470 Kg/m^3	1440-1540 kg/m^3

The Table-1: Physical properties of cement.

Water: For this investigation we are using clean, potable tap water for both mixing and curing as per IS-10262:2009, and the water is free from any contamination like oil, acids. Alkalis, salts or any other organic substance, that may cause negative impact on our concrete. The Table-4.2 shows the Permissible Limits of Water.

Fine Aggregate: For this investigation, we are using fine aggravate of conforming to grading zone II of IS 383:2016. For this purpose, we used sand passed through 4.75 mm IS sieve and retained on 150 µm sieve. The used is clean and free from any impurities.

Table-2: Physical properties of fine aggregate

Sr. No.	Physical properties	Values
1.	Specific Gravity	2.63
2.	Bulk Density	1450 kg/m^3
3.	Fineness Modulus	2.46
4.	Water Absorption	1.20%
5.	Particle Size Range	150 µm – 4.75 mm

Coarse Aggregate: For this investigation, we used crushed angular aggregates such as gravel by confirming the IS coal provision of IS-383:2016. Aggregates are graded by using sieve analysis. The aggregates passing through 20 mm sieve and retained on 4.75 mm sieve were used. They are sieved thoroughly to remove all the dust particles.

Table-3: Physical properties of course aggregate.

Sr. No.	Physical properties	CDA
1.	Specific Gravity	2.68
2.	Blaine Fineness(m2/Kg)	338
3.	Fineness Modulus	7.13
4.	Moisture content	nil
5.	Particle Size Range	4.75 mm – 20 mm

Cow Dung Ash: For this investigation, cow dung patties were used from the agricultural farm. These patties are free from any moisture. Later, the patties are burned under controlled temperature; after cooling it down these burned patties are grounded in fine powder by using hand and by using 90 micron IS sieves the fine powder is thoroughly sieved. From this process we get fine powder of grey colour, which are going to be used as a cement replacement in our study.

Table-4: Physical properties of CDA

Sr.No.	Physical Properties	Values
1.	Specific Gravity	2.72
2.	Bulk Density	1450 kg/m³
3.	Moisture Content	Nil

Coir Fibre: In this investigation, dried coconut fibers were used by finely chopped to a length of less than 2.5 cm. The fibers are free from any moisture content. The coconut fibers are collected from a trade shop and cut to required length.

Fig.-1: Cow dung ash

Fig.-2: Coir fibre

IV.MIX DESIGN

The concrete mix designed for M30 grade of concrete by using IS-10262:2019. Cement is replaced with cow dung ash by 4%, 8%, and 12% and coir fibre of 0.5% of cementitious material were used.

Table-5: Mix proportion (Kg/m^3) and mix ratio for M30

Water (Kg/m^3)	Cement (Kg/m^3)	Fine Aggregate / Sand (Kg/m^3)	Coarse Aggregate (Kg/m^3)
203	461	576	1113
0.44	1	1.24	2.41
22	50	62	120.5

V.RESULTS AND DISCUSSION

Compressive Test: This test is conducted according to IS.516:1959 guidelines. The test is conducted on a standard cubical concrete specimen of the size 15cm x15cm x 15 cm. Cubes were prepared and tested at 7 and 28 days of curing. The cubes were tested in compression testing machine (CTM). The gradual increase of load applied on the surface of the specimen. The maximum load applied to the specimen were noted down. Table-6 shows the compressive strength test for 7-days and 28-days.

The compressive strength is calculated by using the formula,

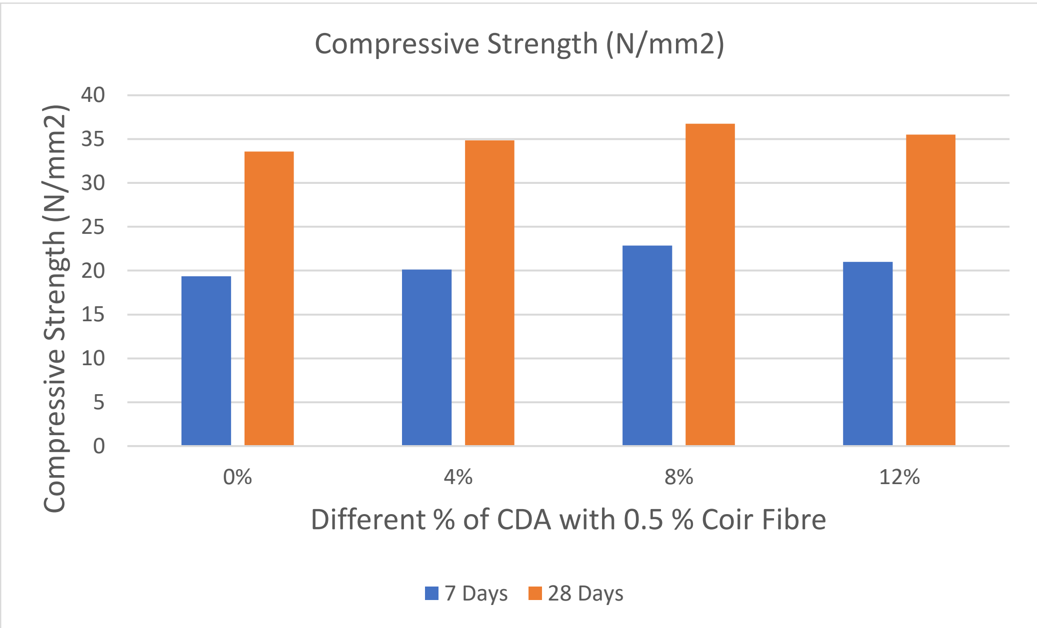
$$\textbf{Compressive strength of specimen(N/mm}^2\textbf{)} = \frac{P}{A}$$

Where,
P – Ultimate load (N)
A – Cross-sectional area of specimen (mm^2)

Table-6: compressive strength results in N/mm^2

Sr. No.	Percentage Replacement of CDA +0.5% Coir Fibre	Compressive Strength (N/mm^2)	
		7 Days	28 Days
1.	0%	19.37	33.59
2.	4%	20.13	34.87
3.	8%	22.86	36.75
4.	12%	21.01	35.52

From the test results, it is observed that the optimum replacement level is achieved at 8% substitution of cement with CDA. The maximum compressive strength recorded at 7 days of curing is 22.86 N/mm^2, compared to 19.37 N/mm^2 for conventional concrete and at 28 days of curing is 36.75 N/mm^2 compared to 33.59 N/mm^2 for conventional concrete. The compressive strength of concrete increases with curing time. This indicates a noticeable improvement in strength with the use of CDA and coir fibre



Bar Chart-1: Tensile strength of concrete at 7 and 28 days

Tensile Test: The tensile strength test is a basic test used to understand how a material behaves when it is pulled or stretched. It helps us know how much force the material can handle before it starts to permanently deform or break. Tensile strength, also called ultimate tensile strength (UTS), is the maximum force a material can withstand before it fails. During the test, a standard specimen is pulled with an increasing tensile force, and its elongation is measured. The results help to understand the strength, ductility, and mechanical properties of the material and determine its suitability for structural application. The results of tensile strength at the age of 7 and 28 days are shown in Table-7

The tensile strength is calculated using the formula,

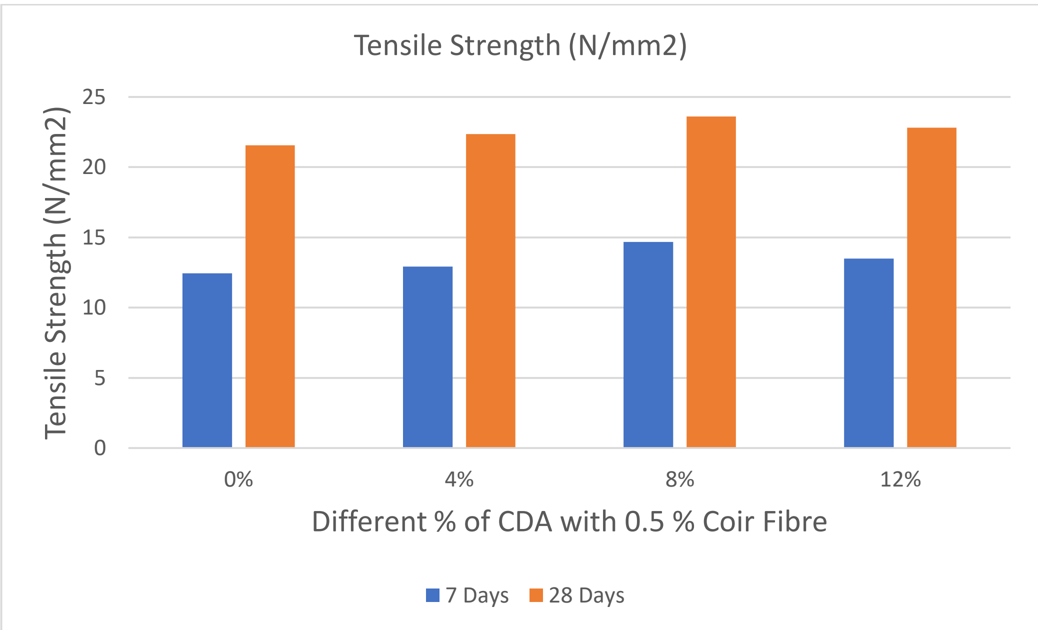
Tensile strength (N/mm^2) = 0.642P/A

Where,
P – Ultimate load (N)
A – Cross-sectional area of specimen (mm^2)

Table-7: Tensile strength results in N/mm^2

Sr. No.	Percentage Replacement of CDA + 0.5% Coir Fibre	: Tensile Strength (N/mm^2)	
		7 Days	28 Days
1.	0%	12.45	21.56
2.	4%	12.92	22.35
3.	8%	14.67	23.60
4.	12%	13.48	22.80

From the test results, it is observed that the optimum replacement level is achieved at 8% substitution of cement with CDA. The maximum tensile strength recorded at 7 days of curing is 14.67 N/mm^2, compared to 12.45 N/mm^2 for conventional concrete and at 28 days of curing is 23.60 N/mm^2 compared 21.56 N/mm^2 for conventional concrete. The tensile strength of concrete increases with curing time. This indicates a noticeable improvement in strength with the use of CDA and coir fibre.



Bar Chart-2: Tensile strength of concrete at 7 and 28 days

VI.CONCLUSION

- From the results it is obvious that the compressive strength and tensile strength of concrete increases with increase in curing days.

- At the 8% of CDA concrete mix gives highest compresive strength of 36.75 N/mm^2 at 28 days compared to 33.59 N/mm^2 for control mix.
- At the 8% of CDA concrete mix gives highest tensile strength of 23.60 N/mm^2 at 28 days compared to 21.56 N/mm^2 for control mix.
- Compressive and tensile strength of concrete gradually increses upto 8% replacement of cement with CDA beyond this % its starts to decrese but its still more than control mix.
- Its observed that CDA absorbs the water so, water absorption increses with increse in CDA percentage.
- The above method of construction of concrete is only suitable for non load bearing structure such as lintel, sunshed, etc.

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