Experimental studies on effect of cow dung ash (pozzolanic binder) and coconut fiber on strength properties of concrete

C Venkatasubramanian*, D Muthu, G Aswini, G Nandhini and K Muhilini
School of Civil Engineering, SASTRA University, Thanjavur – 613 401. India.

*Email: cv@civil.sastra.edu

Abstract. 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 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. The Compressive and Tensile strengths of concrete were found at different curing periods (7, 14 & 28 days). From this study, it is inferred that these replacements will have a reasonable improvement in the strength properties of concrete by about 55-70%. The substitution of CDA, CF is economical in terms of cost and this usage eliminates the problem of landfills, reducing the environmental risk, maintaining the ecological balance, which is very much required for our nation.

1. Introduction
Concrete is the second largest material used by mankind for making the best shelter and taller structures. Due to increase in population, Industrialization, Infrastructural development, etc. there is a demand for both green and cost effective buildings. Concrete is one of the best construction material and has more advantages than other materials in terms of strength, thermal resistance, cost effectiveness. Cement is required for production of concrete which act as a very good binder. But, its production requires more energy and it also lead to pollution. It has been estimated by World Health Organization (WHO) that about 5% of total CO₂ released into the atmosphere is from cement industry. Besides being an environmental pollutant, the amount of heat energy required for production of cement is about 1500 °C which requires more energy. Hence, it is necessary to focus on a material which is of best quality and also involves less energy for its production. Many naturally available materials like coconut fiber, cow dung ash, straw, rice husk ash, etc. are used as binders by partially replacing the cement in concrete. This project work is dealt with incorporation of coconut fiber and cow dung ash in concrete. Coconut fiber is an agricultural waste obtained from fibrous husk of coconut. When it is added to concrete, the workability of concrete decreased, whereas its cohesiveness increased. It was found that coconut fiber incorporation in concrete can decrease about 2 percentage of steel reinforcement decreasing the cost to certain extent. Cow Dung ash is obtained by drying and burning of dried cowdung pats and has large
content of Nitrogen, Potassium, Calcium, Carbon and Phosphorous. It has a low thermal conductivity and requires a maximum of 400°C of heat energy. This method also serves as a good method for reuse of coconut fiber, which is an agricultural and food waste. Incorporation of coconut fiber and cow dung ash in certain amount in concrete proves to improve the strength of concrete. But increase in amount of either coconut fiber or cow dung ash above a certain value may decrease the strength of concrete conversely. So, it is necessary to find out the optimum value of these materials to be added in the concrete which maintains the strength with reduction in cement content. This project deals with the replacement of cement in concrete using cow dung ash and coconut fiber to achieve reduction in cement content with optimum amount of inclusion of these two materials for better strength performance of concrete. This may, in future can lead to use of waste as construction materials at large scale after various research works carried out at various scales.

CDA and RHA with admixtures and plasticizers increased workability and strength of concrete for a range of 0% to 25%. Compressive strength of concrete increased 30% for 5% replacement with CDA and RHA [1]. Coconut fiber enhanced toughness, torsion, cracking and spalling resistance & tensile strength of concrete. A maximum of 3% of Coconut fiber can be used after which strength decreased [2]. Up to 2% of steel reinforcement reduction can be achieved if sizable coconut fibers are used. CFA contains silica, alumina, iron oxides that were found in OPC. Workability decreased with increase in Coconut Fiber ash [3]. With increase in percentage of CDA, Workability, Initial & Final setting time of concrete decreased. CDA has low thermal conductivity & suitable for Light weight structures [4]. Compressive strength of concrete decreased if Cow dung ash of more than 10% by weight of cement is added. CDA needed more water when added to concrete [5]. A maximum of 5% of Cattle Waste Ash (CWA) can be used in small rural housings which reduces cost.

2. Materials and Methodology

In this study, we used CDA and CF as a replacement of cement in concrete, CDA is a good binding material reducing voids in concrete and CF can make the concrete more tough.

2.1 Coconut fiber

Dried Coconut Fibers that were finely chopped to a length less than 1 cm as shown in Figure 1 was used.

2.2 Cement

Cement used in this experimental work was (PPC) Portland Pozzolanic Cement with a specific gravity of 3.20 which passed through 90 μm sieve with a Fineness of 7.1% and Consistency of 30, 30.7, 30.9 and 43.7 % for 0, 2.5, 3 and 3.5 % of CDA respectively.

2.3 Cow dung ash

Cow dung ash (Figure 2) that has been obtained from villages are dried under sunlight, burnt at a temperature of 450 to 500 °C and cooled. After cooling it was crushed to powder form, sieved under 300 micron sieve was stored in an air tight container preventing moisture ingress. Its properties were Specific gravity of ash - 2.55, pH value-9.5, Loss on ignition-12.28%, Blaine’s fineness - 338.
Table 1. Chemical Composition of Cow Dung Ash (CDA) vs Ordinary Portland Cement (OPC)

| Oxide/Oxide | CDA   | OPC   |
|-------------|-------|-------|
| Percentage  |       |       |
| SiO2        | 65.7655 | 20.26 |
| Al2O3       | 4.4575  | 6.30  |
| Fe2O3       | 3.1625  | 3.26  |
| CaO         | 12.98975| 65.51 |
| MgO         | 2.01775 | 0.96  |
| SO3         | 0.9405  | 0.69  |
| P2O5        | 2.83375 | 0.88  |
| Na2O        | 0.511   | 0.89  |
| P2O5        | 1.38275 | 0.25  |
| Mn2O3       | 0.59925 | 0.21  |
| SiO2+Al2O3+Fe2O3 | 73.3855 | -     |
| CaCO3       | 23.18225| -     |
| TiO2        | 0.36875 | 0.24  |

2.4 Coarse Aggregate
Crushed granite that passed through 20mm sieve and retained on 4.75mm sieve was used as coarse aggregate.

2.5 Water
The water used for this experimental purpose was obtained from underground source through pump that was free from bacteria and visible sediments.

2.6 Fine Aggregate
Fine aggregate used for testing satisfied the required properties of fine aggregate conforming to zone 1 as per IS 383:1970.

3. Concrete Mix Design
The Concrete of M-20 grade was made using Binders, Fine and Coarse aggregate with a mix proportion of 1:1.7:3.3 and Water-Cement ratio of 0.45.
4. Casting of Samples
Initially, Cement and Sand were mixed up and added with CDA and CF. Coarse aggregate and Water were added after procuring and weighing them properly and finally were casted to cubes of size 150 mm and cylinders of diameter 150 mm and height 300 mm. After curing, the cubes and cylinders were tested at 7, 14 and 28 days respectively under Universal Testing Machine.

5. Results and Discussion

| S. No. | % of CDA added | Tensile Strength (MPa) |
|--------|----------------|------------------------|
| 1.     | 2.5            | 2.54                   |
| 2.     | 3              | 2.63                   |
| 3.     | 3.5            | 2.92                   |

Table 2. Tensile strength (Cylinder).

| S.No | % of CDA | Days Of Curing | Weight after Curing (kg) | Compressive Strength (MPa) |
|------|----------|----------------|--------------------------|----------------------------|
| 1.   | 2.5      | 7              | 8.54                     | 19.43                      |
|      |          | 14             | 8.60                     | 34.56                      |
|      |          | 28             | 8.56                     | 35.44                      |
| 2.   | 3        | 7              | 8.48                     | 17.22                      |
|      |          | 14             | 8.41                     | 27.34                      |
|      |          | 28             | 8.46                     | 30.10                      |
| 3.   | 3.5      | 7              | 8.44                     | 18.16                      |
|      |          | 14             | 8.36                     | 34.79                      |
|      |          | 28             | 8.23                     | 35.11                      |

Table 3. Compressive strength (cube)
From the results, it was found that the Concrete’s compressive strength increased by about 77.2% and 75.5% for 2.5% and 3.5% replacement of cement using CDA and CFA. The Tensile strength increased by about 46% for 3.5% replacement of cement using CDA and CFA. So, it can be inferred that there was a significant increase in both the Compressive and Tensile strength of concrete for 3.5% replacement of Cement using cow dung ash and coconut fiber.

6. Conclusion
At present, the process of manufacturing of cement involves a larger emission of harmful gases which poses a threat to environment in many ways. Many research works are being carried out to replace either partially or wholly, the fine aggregate, coarse aggregate and cement in concrete. In this project, an attempt has been made to use cow dung ash and coconut fiber as a replacement material of cement. The addition of these materials marginally improved the structural properties of concrete. It also lead to reduction of environmental impact caused by land filling or dumping of these materials. Replacement using these materials can bring down the original cost of production of concrete and it also lead to reuse of waste materials. The above tested methods for production of concrete can be applied in the construction of compound walls, non-load bearing partition walls, lightly loaded precast members-shelf slabs, sill slabs, cut lintels and sunshades, kerb walls and medians of road.

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