Investigation on the Partial Substitution of Cement in Cement Bricks with Coconut Shell Ash

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***Abstract*— This research focuses on CSA (COCONUT SHELL ASH) Cement bricks, which are produced by partially substituting coconut shell ash for cement which is an agricultural waste. Cement is the primary component of cement bricks. Approximately 5% of global CO2 emissions are caused by the calcinations of $CaCo_3$ and fossil fuels during the cement production process. 5 and 10% replacement levels of cement with CSA were used to manufacture cement bricks. When put through several tests, including those for size, shape, structure, impact, soundness, hardness, and efflorescence, the CSA cement bricks created perform well. For replacement of 5% and 10 % of cement with CSA in CSA bricks the water absorption is found to be 11.5%, 12.8% and compressive strength is 8.3N/mm2, 9.4N/mm2 respectively. These results showed CSA bricks have slightly better performance compared to regular red bricks.**

***Keywords*— Coconut shell ash; cement replacement material; mechanical properties; reduce the environmental issue**

I. INTRODUCTION

Brick is one of the important material in the construction of which is widely used and highly demand in the construction of a structure in the civil engineering sector. However, the consumption of natural resources such as sand in brick production resulted in resource depletion, environmental degradation, and energy consumption. The present use of cement is evaluated to be around 12 million tons per year and is yet expanding day by day. The production of cement is very hazardous to the environment as it produces heat and an excessive amount of CO2. Carbon dioxide emissions are a serious environmental problem in cement production. It is a well-known fact that the production of one-ton cement exhaust around one ton of carbon dioxide directly into the atmosphere. Besides, it is accused of producing cement for 5-7% of carbon dioxide emissions from industrial sources Previously most of the researchers have already worked a lot to reduce the use of concrete and replace concrete with such suitable materials, which give the properties like the concrete.

Partial replacement of cement by a combination of materials for the replacement of cement (CRM) is not only economically advantageous but also beneficial due to its mechanical, durable, and micro-structural characteristics. There are many cement replacing materials available in the market for concrete. Some of the most common materials are bagasse (SCBA), limestone powder (LSF), rice husk ash (RHA) and silica fume (SF). In this research project, coconuts shell ash (CSA) is used as agricultural waste. This waste is readily available as there is no other use of this for landfilling. Owing to the environmental issues associated with cement, the partial replacement of cement by a local waste material will not only lessen the requirement of cement in construction projects but also the corresponding dumping of the waste in landfills will be reduced. It was evaluated that CSA has the capability to partially replace cement in cement bricks.

Hasan et al. (2016) conducted the investigational research on hardened concrete binary blended with stone dust (SD) and coconuts shell ash (CSA). In this study, the numbers of specimens were cast for mechanical properties. It was showed the crushing strength, flexural test, and shrinkage test of concrete increased by 7.5%, 3.5%, and 53% while cement replaced with 10% of CSA and SD after 28 days.

Utsev et al. (2012) investigated the study on the crushing strength of concrete inclusion with 0%-30% of CSA. The conclusion demonstrated that the 10% replacement was optimum where the compressive strength improves beyond it decreases.

Bhartiya and Dubey (2018) studied the effects of CSA and ESP content on the crushing strength of concrete.

It was pointed out that the crushing strength was improved by substituting 10% CSA in concrete.

The main purpose of this review study is to investigate the impact of CSA on the fresh and mechanical properties of concrete. The particular objectives of the review studies are highlighted below:

1. To find the water absorption of the CSA bricks.
2. To examine the impact of CSA on compressive strength.

II. MATERIALS AND METHODOLOGY

A. Cement

Locally available 53 grade ordinary Portland cement confirming to IS 12269 is used.

B. Coconut Shell Ash

Coconut shells from local coconut farmers and vendors are bought and processed as following to obtain coconut shell ash. The coconut shell was sun dried for 48 hours to remove moisture from it. This Coconuts shell was burnt under controlled combustion arrangement at 500 ℃ to 550 ℃ temperatures for two hours to produce ash. The coconut shell ash was sieved through #200 sieves to get required fineness.

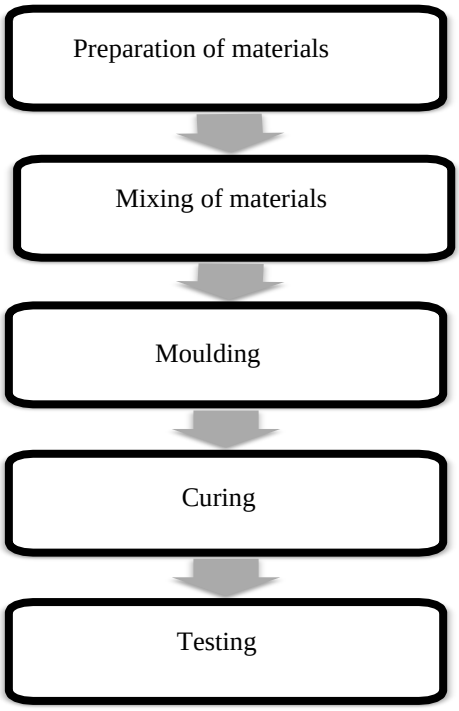
Constituent	OPC	CSA
SiO_3	20.78	37.9
Al_2O_3	5.11	24.12
Fe_2O_3	3.17	15.48
CaO	60.89	4.98
MgO	3	1.89
Na_2O	0.25	0.95
K_2O	0.39	0.83
P_2O_5	0.26	0.32
SO_3	1.71	0.71

C. Sand

Locally available river sand is taken and sieved the fine aggregate conforming to requirements of IS 383.

D. Water

Normal tap water with the PH range between 6 to 8 is used.



E. Preparation of Bricks

Mix the cement, sand, and coconut shell ash in the appropriate proportions. Gradually add water to the dry mix to achieve uniform consistency that is neither too dry nor too wet. Place the mixed material into molds of the desired shape and size. Brick size can be used 230mm x 110mm x 70mm. Use a vibrating table or hand tamper to compact the mixture within the molds and remove air bubbles. The blocks were sprinkled with water on a daily basis during the period of the curing. After the desired curing age has elapsed, the blocks were prepared for the subsequent tests.

I. Water absorption Test

The test specimens shall be completely immersed in water at room-temperature for 24 h. The specimens shall then be weighed, while suspended by a metal wire and completely submerged in water. They shall be removed from the water and allowed to drain for one minute by placing them on a 10 mm or coarser wire mesh, visible surface water being removed with a damp cloth and immediately weighed. Drying Subsequent to saturation, all specimens shall be dried in a ventilated oven at 100”C to 115°C for not less than 24 h and until two successive weighing’s at intervals of 2 h show an increment of loss not greater than 0.2 percent of the last previously determined mass of the specimen.

Figure(a): water absorption test

II. Compressive Strength Test

Place the specimen with flat faces horizontal, and mortar filled face facing upwards between two 3-ply plywood sheets each of 3 mm thickness and carefully centered between plates of the testing machine. Apply load axially at a uniform rate of 14 N/mm^2 (140 kg/cm^2) per minute till failure occurs and note the maximum load at failure. The load at failure shall be the maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine.

NOTE - In place of plywood sheets plaster of Paris may be used to ensure a uniform surface for application of load

Figure(b): Compression strength test

III. RESULT AND DISCUSSION

Results for the compressive strength and water absorption measurements are presented in graphical forms

A. Effect on Water absorption

CALCULATION AND REPORT

Water absorption, percent = (A-B)/B x 100

where A-Weight of wet sample

B- Weight of dry sample

= 2805- 2525.5/2525.5x100

= 279.5/2525.5x100

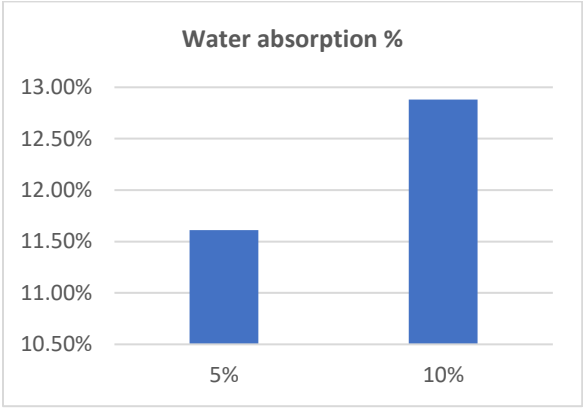
= 11.06%

Specimen	% of CSA added	Weight of dry sample in grams	Weight of wet sample in grams	Water absorption (%)
Sample 1	5	2525.5	2805	11.06
Sample2	5	2584.5	2893	11.93
Sample3	5	2550.3	2845	11.55
Sample 4	10	2411	2721	12.85
Sample 5	10	2485	2794	12.43
Sample 6	10	2395	2715	13.36

Table 1.1: Water absorption test

Average for replacement of 5% CSA = 11.61%

10%CSA = 12.88%



1.1.1: Water absorption with different % replacement

Water absorption for the traditional bricks is 20%. From above graph we can observe that on replacement of 5% cement with CSA we obtain 11.51% and with 10% replacement we obtain 12.88% . The water absorption in CSA cement bricks is less than traditional bricks. So, the CSA cement bricks are more durable

B. Effect of CSA on Compressive Strength

CALCULATION AND REPORT

Compressive strength

= Load at failure(N) / surface area(mm^2)

= 205430/25300

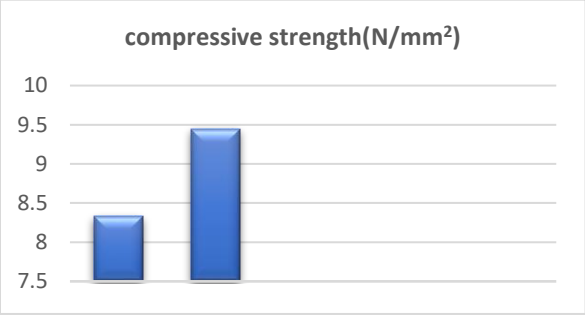
= 8.12 N/mm^2

Specimen	% of CSA added	Load at failure (KN)	Loaded area (mm^2)	Compressive strength (N/mm^2)
Sample 1	5	204.43	25200	8.11
Sample 2	5	215.06	25200	8.53
Sample 3	5	212	25200	8.41
Sample 4	10	232.51	25200	9.22
Sample 5	10	238.59	25200	9.46
Sample 6	10	242.89	25200	9.63

Table 1.2: compression strength test

Average for replacement of 5% CSA = 8.33N/mm^2

10%CSA = 9.44N/mm^2



1.2.1: compressive strength with different % replacement

Compressive strength for the traditional bricks is 10N/mm^2. From above graph we can observe that on replacement of 5% cement with CSA we obtain 8.33 N/mm^2. and with 10% replacement we obtain9.44 N/mm^2. The compressive strength of CSA cement bricks is similar to traditional bricks.

Performance Evaluation

property	CSA brick
Water absorption in %	11-13%
Compressive strength in N/mm^2	10 /mm^2

IV. CONCLUSION

- By the field tests like size test, colour test, structure test, sound test, impact test, hardness test & efflorescence test. It is concluded that the produced CSA cement bricks are good quality bricks.
- Water absorption for CSA cement bricks with 5% and 10% of cement replacement by CSA is 11.51% and 12.88% respectively which is less than 20%.
- The average compressive strength for bricks with 5% and 10 % replacement of cement with CSA is 8.33N/mm^2 and 9.44N/mm^2 respectively.
- From this we can conclude that the CSA cement bricks can be used in place of the traditional bricks present in market for construction works.
- Further researching by using various mix proportion combinations with CSA and some other materials like groundnut shell ash, egg shell ash, etc., characteristics of bricks can be improved.

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