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Performance of Recycled Paper Pulp And Fly Ash In Production of Light Weight Bricks

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Abstract

In terms of sustainable and cleaner production, the utilization of Paper wastes in the manufacturing of eco-friendly building materials has attracted attention in recent years. In the present study, Papercrete fly ash based bricks were produced to determine the influences of paper pulp and fly ash on the physical, mechanical, and thermal properties of bricks. The following parameters were examined for the bricks produced at Office paper and newspaper; water absorption, apparent porosity, efflorescence, bulk density, compressive strength, and thermal conductivity. For the brick production, Fly ash was used up to 30% up to 50%.

Keyword: *Papercrete, Fly ash brick, Thermal insulation, Lightweight brick*

1. Introduction

Papercrete is a sustainable construction material that consists of re-pulped paper fiber with Portland cement. It is apparent as an environmentally friendly material due to significant recycled content. Its annual energy consumption exceeds that of all the other engineering materials[1,2]. These days carbon emission from construction sites due to the use of cement is globally issued[3,4]. The brick places a major role in the protection of building from the outer environment and their physical and mechanical properties helps to determine the energy demand of the building and provide the thermal comfort to the occupant [5–9].

On the other hand, people's desire to live eco-environment is continuously increasing. An probable seven percent of the global carbon dioxide emits during manufacturing process of the concrete [2,4]. Papercrete is new composite material. By using the waste paper, papercrete is reducing the dead load for the structure[10,11].And the papercrete have good impact absorbing property[12,13].

The huge requirement has been positioned on construction building material industry particularly in the most recent decade owing to the growing population which causes a chronic scarcity of construction materials, This experimental study investigates the potential use of waste paper for producing low-cost and lightweight composite concrete[14–16]. This alternative concrete was made with papercrete.

PAPER + CONCRETE = PAPERCRETE

Papercrete is a type of fibrous cement, made by shredding paper into pulp in water and adding Portland cement. The thick mix can be poured into molds and cast like concrete. When cured and dried papercrete is strong, lightweight, insulating[17–19], and has many properties that make it an ideal building material[20].

2. Materials and methods

In this project waste materials were utilized to produce concrete. The following materials were used in this investigation,

2.1. CEMENT

The physical properties of Cement is given in the Table 1. which used as the binding materials, 53 grade Ordinary Portland Cement (OPC) is used.

Table 1 PHYSICAL PROPERTIES OF CEMENT

Physical properties of cement	Test results obtained	The requirement of IS:8112 1989
Specific gravity	3.15	3.10 – 3.15
Initial setting time	65 minutes	Min. 30minutes
Final setting time	270 minutes	Max. 600minutes
Fineness	412.92 m^3/kg	Min.225 m^2/kg
Compression strength – 7 days	39 N/mm^2	43 N/mm^2
Compression strength – 28 days	52 N/mm^2	53 N/mm^2

2.2. FLYASH

wooden fly ash is used which comes as the byproducts of steam power plants and other thermal power generating industries. while wood is a renewable resource for energy and environmentally friendly material, there is an increased interest in using “waste” wood for energy production. chemical and physical properties of wooden fly ash are shown in Table 2 & Table 3.

Table 2 PHYSICAL PROPERTIES OF WOOD ASH

Parameter	Fly Ash	
	Average	Range
Retained on No.325 Sieve, (%)	46	3.6 – 98.3
As-received Moisture Content, (%)	15	0.9 – 42.3
Specific Gravity	2.45	2.32 – 2.76
Strength Activity Index with Cement (% of control) 28 days	73	48.9 – 123.8
Water Requirement (% Control)	118	103 - 155
Autoclave Extension, (%)	0.10	0.01 – 0.63
Unit Weight, Kg/m^3	548	162 – 1376

Table 3 CHEMICAL COMPOSITION OF WOOD ASH

Constituent	Fly ash	
	Average (%)	Range (%)
Silicon dioxide, SiO_2	26.5	4.0 – 59.3
Aluminum Oxide, Al_2O_3	9.0	5.0 – 17.0
Iron Oxide, Fe_2O_3	5.4	1.0 – 16.7
SiO_2 +Al_2O_3 +Fe_2O_3	40.7	10.0 – 72.2
Calcium Oxide, CaO	16.0	2.2 – 36.7
Magnesium Oxide, MgO	3.0	0.7 – 6.5
Titanium Oxide, TiO_2	0.51	0.0 – 1.2
Potassium Oxide, K_2O	5.0	0.4 – 13.7
Sodium Oxide, Na_2O	1.7	0.5 – 14.3
Sulfate, SO_3	4.8	0.1 – 15.3
Loss on Ignition, LOI	23.4	6.7 – 58.1
Moisture Content	2.6	0.1 – 21.5
Available Alkali, Na_2O Equivalent	3.3	0.4 – 20.4

2.3. WASTE PAPER

Wastepaper used in this project was collected from schools, colleges of housing buildings, and planning Administration office, The physical property of the waste paper is discussed in Table 4.

Table 4 PHYSICAL PROPERTIES OF WASTE PAPER

Properties	Wastepaper	
	Office paper	Newspaper
Moisture content (%)	2.67	4.17
Specific gravity	0.98	0.81
Absorption(%)	197.54	207.50

2.4. PULPING THE WASTEPAPER

The collected waste papers cannot be used directly in the concrete mix. It need be made into paper pulp previous to assimilation with other ingredients. The following are the steps implicated in the making of pulp [21]. In our project new paper is used because of its good properties while compare with the office paper.

- First, the pins, threads, and other foreign materials in the papers were removed.

- Then the waste papers were cut into small pieces using waste paper Shredder machine.
- Then, a 200-liter water tank was taken. And 2/3rd of it was filled with water.
- Then the small pieces of paper were immersed in the water tank. The paper pieces were immersed individually not in a bulky manner to make the pieces completely wet. Before immersed it into the water, the papers were weighed. The figure shows the papers were being immersed in the water tank.
- The papers were immersed in the tank full of water until it transferred to paste like consistency. Then the paper paste was taken out from the tank then filtered and taken to the mixer machine to formulate it a paper pulp. The waste paper pulp manufacturing procedure was monotonous and time consumption.
- For lab purposes, only these procedures were followed. while mass manufacturing the Tow mixers were suggested to reduce the time and cost. The Tow mixers have sharp blades and it can operate mechanically or electrically.

2.5. MIXING

subsequent to the process of generating waste paper pulp, all the ingredients are mixed and ensure the proper mixing of concrete. In this project, the mixing was done concrete mixer at speed of 30rpm for 5min and task repeated for 3 times and ensure consistency of concrete [15]. The mixing process of fibrous concrete is different from conventional concrete, and that process is given below. The accurate and effective cum optimum mix proportion was not known. so, trial proportions were used in this project and its listed in Table 5.

Table 5 MIX PROPORTION

		Trial mix				
Sl.No	**Identification mark**	**Ingredients (%)**				**Dr.Fixit 101 LW+**
		cement	**paper**	**Coarse aggregate**	**Fly ash % of the weight of cement**	
1.	F30	1	2	4	30%	50ml
2.	F40	1	2	4	40%	50ml
3.	F50	1	2	4	50%	50ml

2.6. PAPERCRETE MIX RATIO

The weight batching done as per the mix proportion provided in the Table 5 and safe PPE are taken care and mix done using the mixer machine, totally 70 bricks where casted in each cases and samples used for the required series testing.

The bricks casted in the size of 190mm × 90mm × 90mm using the manual brick molding machine shown in Figure 1.

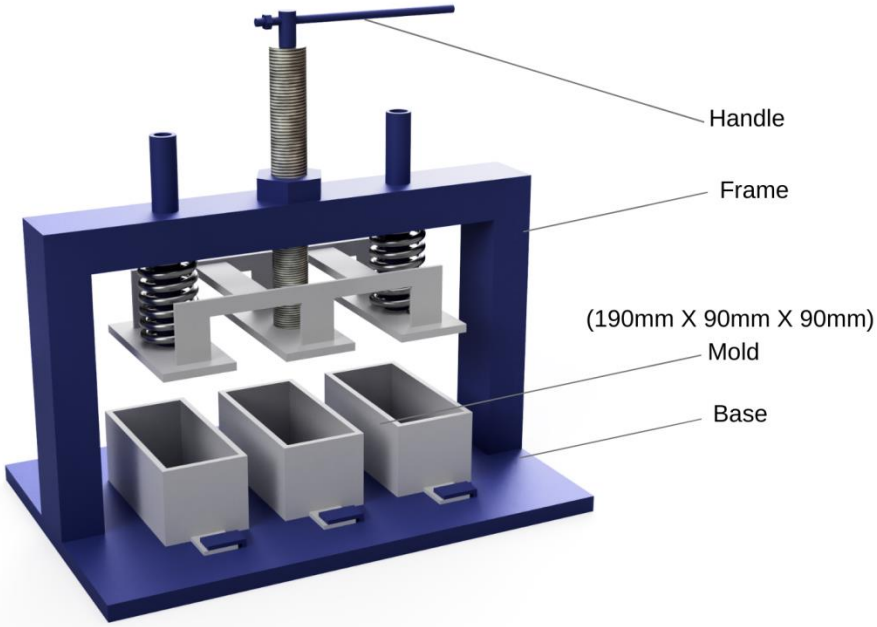

Figure 1 Design of Manual Brick Mould

3. Test methods

The sequence of Experimental tests have been carried out as per the standard ASTM C67-03a to find out compression strength, The water absorption test did as per (IS3495 (Part 2): 1992), specific weight, voidage and equilibrium moisture content, dimension change on drying (IS 1077: 1992).

4. Results and discussion

The various test was conducted in the papercrete concrete cubes are given below,

4.1. WEIGHT

The regular conventional concrete cube weight varies from but the papercrete concrete cubes weight varies from. The maximum weight is less than 7kg only. In this above proportion fly, ash is having 1/3rd of the conventional concrete weight only. So this concrete is lightweight and it will reduce the total cost of construction due to the reduction in dead load.

Table 6 WEIGHT OF PAPERCRETE BRICK

S.No	Identification Mark	% of Fly ash	Dry Weight (Kg)
1	F30	30	2.64
2	F40	40	2.72
3	F50	50	2.81

form the Table 6 while increasing the percentage of fly ash plays the major in the weight of the brick. its clearly showing that weight is directly proportion to the content of the fly ash in the brick.

4.2. WATER ABSORPTION TEST

- Dry the sample in ventilated over at a temperature of 105° C to 115° C till it attains significantly constant mass.
- chill down the sample to room temperature and obtain its weight (M1) sample too warm to touch shall not be used for this purpose.
- Immerse completely dried specimen in clean water at a temperature of 27+2°C for 24 hours.
- Remove the specimen and swipe out any trace of water with a damp cloth and weight the specimen after it has been removed from water (M2).

Table 7 WATER ABSORPTION TESTING VALUE

Mix Cases	Water Absorption results in % (24 hours)		
	F30	F40	F50
	37.51	29.67	18.93

from the Table 7 while increasing the percentage of fly ash it impact on the water absorption as per the Indian standard the first bricks need not to be more than 20 percentage by weight. F50 case only passed as first class brick in the water absorption test

4.3.COMPRESSION TEST

This test was carried out by a compression testing machine. This test was carried out on the 7th and 14th day from the date of casting papercrete concrete. While testing the papercrete concrete great care must be taken, because papercrete concrete never failed catastrophically, it just compressed like squeezing rubber. So load was applied up to half compression.

When papercrete concrete cube failed at the higher load, the structure was not fully collapsed. Only the outer faces cracked and peeled out. The papercrete concrete is having elastic behavior and less brittleness.

The following steps were followed for compression testing.

- First, the irregularities of the surface were removed.
- The concrete cube was placed centrally on the bottom plate of the universal testing machine.
- Then the upper plate of the universal testing machine was lowered down up to the concrete cube was hold tightly without any movement.
- Then the load was applied axially at a uniform rate.
- This load was applied to half of the concrete cube.
- Three concrete cubes from the same proportion were tested every time.

Table 8 COMPRESSION TEST VALUES OF PAPERCRETE CONCRETE CUBE

Compression strength in N/mm^2			
Days	**F30**	**F40**	**F50**
7 days	0.22	0.35	0.48
14 days	1.15	2.48	3.42
28 days	10.08	17.42	23.95

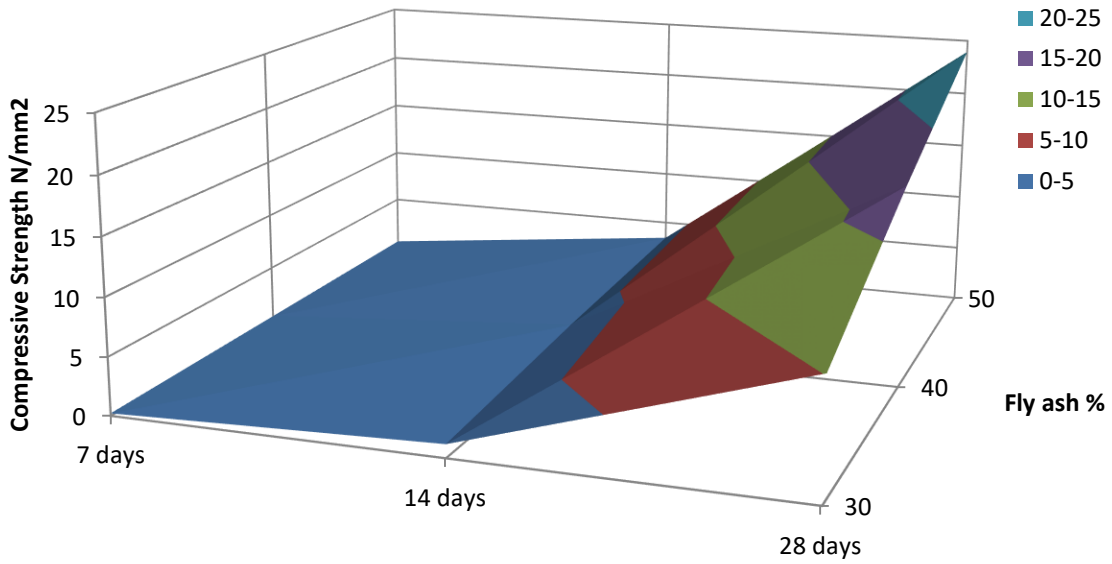

Figure 2 Compressive Strength

form the Figure 2 its showing the compression strength at 7, 14 and 28 days air cured samples of the different cases with varying percentage of fly ash. Y - axis showing the compressive strength and X - axis for tested days and Z - axis represents the percentage of fly ash in the brick. its plotted in surface chart to understand the behaviour of brick under compression testing on curing days.

5. Conclusion

The mechanical and physical behavior of Recycle paper pulp with fly ash based brick are discussed. From the results its can be observed F50 having higher performance while compare with other cases. It can be utilized for the thermal insulation which helps to provide the thermal comfort [9] and also for lightweight construction.

From the above experimental studies, we can conclude that,

- Papercrete concrete is suitable for non-load bearing walls only.
- The weight of this concrete is lesser than the conventional concrete.
- This concrete is not suitable for water logging and external walls. It can be used in inner partition walls.
- Due to less weight of this concrete, the total dead load of the building will be reduced.
- Since this concrete is relatively lightweight and more flexible, this concrete is a potentially ideal material for earthquake-prone areas.
- Papercrete concrete does not expand or contract, so sheets of glass or glass block can be embedded in and trimmed with papercrete.
- Paper can be used successfully as fine aggregate for making concrete by replacing ordinary river sand.
- Papercrete has high fire resistance.
- Papercrete made with the newspaper has better structural properties than those made with office paper but it also has a higher water absorption capacity.

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