Experimental Investigation on Papercrete Bricks

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Abstract— the major constituent in any construction activity is cost of the materials. In developing countries, the untapped or unused resources are needed to be identified for its potential usage in the construction sectors. A huge quantity of non-renewable resources is consumed by the construction industry throughout the world. The one such resource is waste papers. Everyday tons of waste papers are discarded as landfill or dump sites than those recycled. It is found that around fifteen trees are required to make a ton of paper which means that 720 million trees are used once and then buried as landfills each year. In this research paper, an attempt is made to produce an alternative material using waste papers (newspapers) in order to find out their suitability to use as a building construction material by determining the compressive strength, weight and cost of bricks. This could help to eradicate a few environmental hazards caused by the construction industry. In this study, three different mix proportions were tried by utilizing the waste Paper and industrial by products like Fly ash and eggshells as cement replacement materials. The self-weight of bricks made by using paper pulp with cement and sand is approximately 50% lesser than the conventional bricks. By the use of papercrete bricks the dead weight of the structure is reduced to a considerable amount.

Key words: Papercrete, Fly Ash, Egg Shell, Weight, Compressive Strength, Cost of Bricks

I. INTRODUCTION

Chronic shortage of building materials is caused due to the large demand on building material industry owing to the increasing population, since the last decade. This has become a major challenge to civil engineers to turn out and use alternate materials. The constant developmental activities in civil engineering and growing industrial activities have created a continuous demand for building materials which satisfy all the stringent requirements regarding the short-term and long-term performance of the structure. India's present housing shortage is estimated to be as high as 31 million according to census and out of these shortages 24 million units are in rural areas and 7 million units in urban areas. A huge amount of money is required for such a large housing constructional activity. In developing countries like India, out of this total cost of construction of house, materials used for building contribute to about 70% of cost. This experimental study investigates the potential use of waste paper for producing a low-cost and light weight composite brick as a building material. These alternative bricks were made with papercrete. In the present scenario, the whole world is facing a major problem of environmental pollution by the waste industrial materials like Fly ash, egg shell, quarry dust etc., as they are dumped as landfills. Hence these materials can be used as alternatives in the construction industry which will help meeting the sustainable development requirements. A conventional brick is consists of fly ash of 60%, sand of 30%, lime and gypsum of 10%. In this paper, the brick is made up of papercrete of 58%, sand, fly ash, quarry dust, egg shell of 30%, and cement of 12%. The experimental investigations are made and the results are discussed.

II. LITERATURE REVIEW

Rohit kumar arya et al. (2013) have used sand, cement, paper sludge (1:1:3) for the manufacturing of brick. By conducting various experimental investigation it have been found that the compressive strength, hardness of bricks are increased.

Selvaraj.R., et al. (2015) have used papercrete as a brick material mixed with ordinary Portland cement, sand, coarse aggregate of various mix proportions. By conducting various experimental investigations the compressive strength, flexural strength and split tensile strength of cubes and cylinder casted concrete are found out.

Myriam Marie Dalcasse et al. (2017) have used papercrete for the manufacturing of bricks with cement and river sand. The strength of bricks get increased by the addition of papercrete.

A. Materials

1) Cement

The binding material used for this study is Ordinary Portland cement of 53 grades conforming to IS 456-2000. The limestone is heated with small quantities of other materials such as clay in a kiln to about 1450°C known as process of calcinations for the manufacturing of cement. The properties of cement is shown in Table 1.

Description of test	Test results obtained	Requirements of IS: 8112 - 1989
Initial setting time	65 minutes	Min. 30 minutes
Final setting time	270 minutes	Max. 600 minutes
Fineness (specific surface by Blaine's air permeability test)	412.92m^2/ kg	Min. 225m^2/ kg
Soundness of cement (by Le-chatlier method)	0.2 mm	Max. 10 mm
Compressive strength of cement mortar cubes at:		
3 days 7 days 28 days	25.53N/mm^2 33.97 N/mm^2 47.94 N/mm^2	23 N/mm^2 33 N/mm^2 43 N/mm^2

Table 1: Properties of cement

2) Sand

Fine aggregate used in this study was Natural river sand. As per IS: 2386 (Part- I) the properties of sand were determined. Locally available river sand used in this project having a fineness modulus of 2.92, specific gravity of 2.62 and conforming to grading zone-II as per IS: 383-1970.The sieve analysis of sand is shown in Table 2.

IS sieve size	Weight retained, kg	% weight retained	% weight passing	Cumulative % weight retained	Requirements of IS: 383 - 1970 for grading zone II
4.75 mm	0.00	0.0	100.0	0.0	90 - 100
2.36mm	0.04	2.0	98.0	2.0	75 - 100
1.18mm	0.67	33.5	64.5	35.5	55 - 90
600µ	0.50	25.0	39.5	60.5	35 - 59
300µ	0.67	33.5	6.0	94.0	8 - 30
150µ	0.12	6.0	0.0	100.0	0 - 10
Total				292.0	
Fineness modulus = (292/100) = 2.92					

Table 2: Sieve Analysis of Sand

3) Water

One of the important ingredient involving in the chemical reaction with cement is water. For both soaking and mixing of papercrete potable water should be used. Suspended solid matter in the water shall not exceed more than 200mg/l, the pH value of the water shall not less than 6.

4) Fly Ash

Compared to cement Fly ash is very fine, however some particles have size less than 1 micron in equivalent diameter. It is produced by combustion of broken up coal or lignite in thermal power plants. Table 3 shows the chemical composition of fly ash.

Components	Percentage (%)
Silica as Sio_2	35-59
Iron as $Fe2O_3$	0.5-2
Alumina as $Al2O_3$	20-33
Calcium as CaO	5-16
Magnesium as MgO	1-5.5
Sulphate as So_3	0.5-1.5
Loss on ignition	1-2

Table 3: Chemical composition of Fly Ash

5) EGG Shell

The eggshells are hard and strength in nature which is rich in Calcium carbonate ($CaCO_3$). An average of 2.2 grams of calcium will be available in a good quality eggshell in the form of calcium carbonate. The weight percentage of $CaCO_3$in eggshell powders shown in table 4.

Sample	% of $CaCO_3$
Trial 1	96.70%
Trial 2	98.39%
Trial 3	94.80%
Average % of $CaCO_3$	96.63%

Table 4: Weight percentage of $CaCO_3$ in egg shell powder.

6) Quarry Dust

Quarry dust is a fine rock particles formed by breaking of boulders into small pieces. It is like fine aggregate and usually appears in grey colour. The basic tests on quarry dust were conducted as per IS-383-1987 and its specific gravity was around 1.95.

7) Water Proofing Powder

Waterproofing Powder is comprised of waterproofing additives, dispersed in static fine filler. It is an integral powder-waterproofing admixture used for waterproofing of concrete and cement plasters, because it makes concrete cohesive, reduces porosity & improve water tightness, reduces water absorption. Meets the requirements of IS: 2645 – 1983 standard.

8) SBR Latex Polymer

Emulsion polymerized styrene-butadiene rubber (E-SBR) is one of the most widely used polymers in the world today. Natural rubber is restricted by its high molecular weight, low miscibility with low molecular weight resins, low polarity and low UV and thermo-oxidative stability resulting in discoloration during the lifetime of a PSA product. Diffusive bonding provides the strong interaction at the interface.

9) Paper

Paper is a natural polymer which consists of wood cellulose. Cellulose is made of units of monomer glucose. Although containing several hydroxyl groups, cellulose is water insoluble. The reason is the stiffness of the chain and hydrogen bonding between two OH groups on adjacent chains. The chains also pack regularly in places to form hard, stable crystalline region that gives the bundle chains even more stability and strength. The cellulose hydrogen bonds is shown in Figure 1.

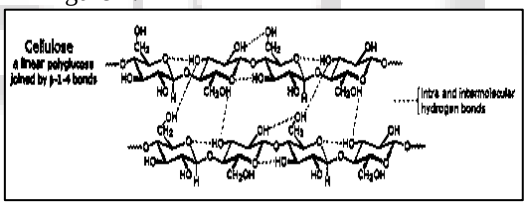

Fig. 1: Cellulose hydrogen bonds

The above figure shows the network of cellulose fibers and smaller offshoots from the fibers called fibrils. Coating this fiber with Portland cement creates a cement matrix, which encases the fibers for extra strength.

Various type of papers can be used for making papercrete such as newspaper, magazines, old invitation cards, paper tickets etc. Before mixing with other ingredients the paper should be made into paper pulp.

III. EXPERIMENTAL INVESTIGATION

In this project, manual mixing was carried out by collecting all the materials and after that it was placed in a mould within 30 minutes. The moulding of bricks was carried out by hand moulding. No hard procedure is done for casting the bricks, because paper has the property to hold the water for long time. The detail of mix methodology is shown in Table 5.

Mix No.	Mix proportions (by weight basis)						Water proofing powder & SBR latex polymer
	Cement	Egg shell	Fly Ash	Quarry dust	Sand	Paper	
Mix1	1	1	0.25	0.25	0.5	4	20% (by the wt. of Cement)
Mix2	1	0.5	0.75	0.5	0.25	4	
Mix3	1	0.5	0.75	0.5	0.5	4	

Table 5: Details of Mix Methodology

A. Compression Test

The strength of the brick was found by the compression test. Universal testing machine was used for this test. This test was carried out on the bricks of 28th day from the date of casting. The average compressive strength of brick for various mix is shown in Table 6.

Trial Mix	Average Compressive Strength (N/mm^2)
M1	2.77
M2	11.86
M3	3.52

Table 6: Average compressive strength on Brick

B. Weight

One of the main aims of the project is to produce a Lightweight brick6. A well-conditioned electronic weighing machine was used to test the weight of all bricks. The weight of papercrete bricks are shown in Table 7.

Mix	Average weight (Kg)	Average weight (N)
Mix 1	1.165	11.43
Mix 2	1.137	11.15
Mix 3	1.225	12.02

Table 7: Weight of Papercrete Bricks

C. Cost Analysis

The aim of this project is to produce a low cost brick. for all proportions of mix 1, 2, 3 the Cost was calculated and cost for production of 100 brick was calculated. From that, then finally cost of one brick was calculated. The Table 8 shows the cost of bricks.

Mix No.	Mix proportions (by weight basis)							Total cost of	
	Cement	Egg shell	Fly Ash	Quarry dust	Sand	Paper	Admixtures	100 bricks (Rs.)	One brick (Rs.)
Mix1	74.29	3.32	0.53	2.78	5.35	64.6	31.47	182.34	1.823
Mix2	57.82	1.15	1.60	5.55	2.67	61.64	31.47	161.9	1.619
Mix3	82.15	1.66	1.07	5.35	5.55	74.44	31.47	201.69	2.016

Table 8: Cost of Bricks

IV. Result and Discussion

The compressive strength of brick should be more than 3.5N/mm² the strength of brick for mix 2 is highly increased and mix 3 is above 3.5 N/mm². But the strength of brick for mix 1 is less than 3 N/mm

The weight of papercrete bricks varies from 11 to 12 N which results in light weight bricks when compared to ordinary conventional bricks whose weight varies from 30 to 35 N.

The rate of papercrete bricks varies from .1.5 – Rs.2.0 when compared to rate of normal conventional clay brick which varies from Rs.2.5 – Rs.3.5. So, the total cost of papercrete brick is less for about 45% to 84% of conventional brick.

The overall comparison graph of compressive strength, weight and cost of bricks is shown in fig 2.

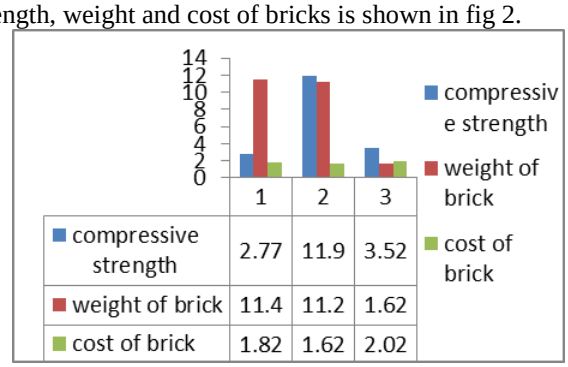

Fig. 2: Comparison graph of compressive strength, weight and cost of brick

V. Conclusion

These bricks can be used in inner partition walls and for non - load bearing partition walls. And these bricks are not suitable for water sorting and exterior walls.

The total dead load of the building will be greatly reduced by this papercrete brick because of its less weight.

Since, these bricks are comparatively light weight and more flexible.

Because of its more water absorbing property this bricks cannot be used for load bearing walls and it can be reduced by some admixtures.

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