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Experimental Investigation of light weight Bricks using paper sludge

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***Abstract* — In this project a parametric experimental study which investigates the potential use of paper waste for producing a low-cost and light weight composite brick as a building material. These alternative bricks were made with papercrete. An experimental investigation has been carried out to study the compressive strength, unit weight, and water absorption. In this study, three different mix proportions were tried by utilizing the waste Paper and Industrial by products like Fly ash, Quarry dust and Eggshells as replacement materials. The results shows that the effect of high-level replacement of paper wastes does not exhibit a sudden brittle fracture, and it reduces the unit weight dramatically and to the current conventional bricks and concrete blocks in the market. This innovative cost effective bricks can be used for walls, wooden board substitute and best alternative for conventional bricks.**

***Keywords* — Papercrete bricks, abandoned paper waste, Compressive Strength**

Introduction

Since the large demand has been placed on building material industry especially in the last decade owing to the increasing population which causes a chronic shortage of building materials, the civil engineers have been challenged to convert the industrial wastes to useful building and construction materials. Accumulating of unmanaged wastes especially in developing countries has resulted in an increasing environmental concern. Recycling of such wastes as building materials appears to be viable solution not only to such pollution problem but also to the problem of economic design of buildings. The increase in the popularity of using environmentally friendly, low-cost and light weight construction materials in building industry has brought about the need to investigate how this can be achieved by benefiting to the environment as well as maintaining the material requirements affirmed in the standards**.**

MATERIALS

1. CEMENT

Cement is made by heating limestone (calcium carbonate) with small quantities of other materials (such as clay) to 1450°c in a kiln, in a process known as calcination, where by a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which is then blended with the other materials that have been included in the mix. The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum into a powder to make 'ordinary portland cement, the most commonly used type of cement (often referred to as opc). Portland cement is a basic ingredient of concrete, mortar and most non-speciality grout. The most common use for portland cement is in the production of concrete.

TABLE - PROPERTIES OF CEMENT

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)	412.92 m2/kg	Min. 225 m2/kg
Compressive strength of cement mortar cubes at: 3 days 7 days 28 days	 25.53 N/mm^2 33.97 N/mm^2 47.94 N/mm^2	 23 N/mm^2 33 N/mm^2 43 N/mm^2

2. SAND

Locally available river sand having a fineness modulus of 2.92, specific gravity of 2.62 and conforming to grading zone-II as per IS: 383-1970. Table gives the details of sieve analysis of sand.

TABLE II: RESULTS OF SIEVE ANALYSIS OF SAND

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					

3. WATER

Water used for mixing and curing of concrete shall be clean and free from oils, acids, alkalis, salts and organic materials or the other substances the may be deleterious to concrete or steel. Portable water shall be used for mixing of concrete. 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 .FLYASH

About 80% of total ash is in finely divided form, which is carried away with flue gases and is collected by electrostatic precipitator or other suitable technology. This ash is called as dry ash or chimney or hopper ash. The balance 20% of ash gets collected at the bottom of the boiler and is referred as bottom ash. Fly ash is very fine comparable to cement, however some particles have size less than 1 micron in equivalent diameter.

TABLE III: 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

5. EGG SHELL

A good quality eggshell will contain, on average, 2.2 grams of calcium in the form of calcium carbonate. Approximately 94% of a dry eggshell is calcium carbonate and has a typical mass of 5.5 grams,1 although these values can differ depending on sources. Amounts as low as 78% have been published. The remaining mass is composed largely of phosphorus and magnesium, and trace amounts of sodium, potassium, zinc, manganese, iron, and copper. In the case of brown versus white eggs, a definitive difference in calcium carbonate amounts may be hard to uncover. However, consider this. The color of the eggs is nothing more than a result of a different breed. The quality, nutritional value, and taste are identical between white and brown eggs, though two notable differences are size and price.

TABLE IV: WEIGHT PERCENTAGE OF $CACO_3$ IN EGG SHELL POWDER

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

6. QUARRY DUST

The basic tests on quarry dust were conducted as per IS-383-1987 and its specific gravity was around 1.95. Wet sieving of quarry dust Through a 90 micron sieve was found to be 78% and the corresponding bulking value of quarry dust was 34.13%. The dust is selected from the nearest source as raw materials. The quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregates of different sizes.

7. WATER PROOFING POWDER

Dr. Fixit Powder Waterproof is composed of waterproofing additives, dispersed in inert 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. Meets the requirements of IS : 2645 – 1983 standard. As an effective pore filler, helps to fill capillaries and pores to prevent water seepage. Most economical water proofing additive, reduces water absorption.

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 (NR) was the earliest polymer used in manufacturing pressure sensitive adhesives (PSA). In today's applications it is typically used as a raw material to formulate adhesive products. Relative to other polymers, natural rubber is limited 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. The NR-NR interface becomes an organic part of a NR film. Upon initiating the separation of the interface, i.e., opening a mailing envelope, a NR adhesive typically delaminates from the carrier paper or film and provides tamper evidence. Diffusive bonding provides the strong interaction at the interface.

9. PAPER

Paper is principally wood cellulose. Cellulose is natural polymer. And Fig.1 shows the links of cellulose bonds. The cellulose chain bristles with polar-OH groups. These groups form hydrogen bonds with -OH group on adjacent chains, bundling, the chain together. The chains also pack regularly in places to form hard, stable crystalline region that give the bundled chains even more stability and strength.

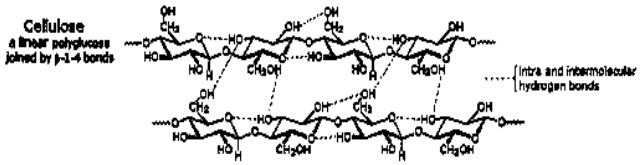

Fig 1: Cellulose hydrogen bonds

Fig 2 shows the network of cellulose fibres and smaller offshoots from the fibres called fibrils. In this, fibres and fibrils network forms a matrix, which becomes coated with Portland cement. When these networks of fibers and fibrils dry, they intertwine and cling together with the power of hydrogen bond. Coating this fiber with Portland cement creates a cement matrix, which encases the fibers for extra strength. Of course paper has more in it than cellulose. Raw cellulose has comparatively rough texture. Clay, rice husk ash is added to make the cellulose very smooth. While adding more sand or glass to the mix results in a denser, stronger, more flame retardant material, but adds weight and reduces R- value. Heavy mixes with added sand, glass etc., increases strength and resistance to abrasion, but also reduces flexibility somewhat, adds weight and may reduce R-value. So the trick is finding the best mix for the application. This mould was prepared with a non-water absorbing plywood material in the size of 230mm length, 110mm wide and 80mm deep. The papers, which were collected, cannot be used directly. It should be made into paper pulp before mixing with other ingredients.

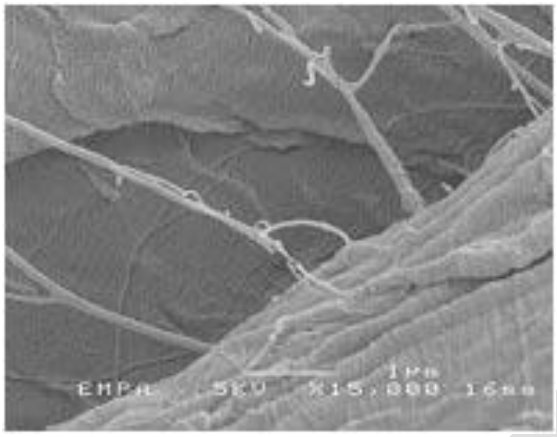

Fig 2 : Microscopic view of cellulose

- METHODOLOGY

After all the ingredients were ready, the mixing was done. In these investigations, mixing was done manually. After mixing, it should be placed in the mould within 30 minutes. The bricks were moulded manually by hand ie., hand moulding. And these bricks were ground moulded bricks. And there was no special care was taken for curing, because paper used to hold water for long time. So, only sun drying was allowed. In this, the bricks were laid longitudinally in stacks of width equal to 2 bricks. The bricks were laid along and across the stack in alternate layer.

Mix proportion = 1 : 2 : 4

TABLE V: DETAILS OF METHODOLOGY

Mix No.	Mix proportions (by weight basis)						Water proofing powder & SBR latex polymer
	Cement	Egg shell	Fly Ash	Quarry dust	Sand	Paper	
M1	1	0.5	_	1	0.5	4	20% (by the wt. of Cement)
M2	1	_	1	1	_	4	
M3	1	_	1	0.5	0.5	4	
M4	1	1	0.25	0.25	0.5	4	
M5	1	0.5	0.75	0.5	0.25	4	
M6	1	0.5	0.5	0.5	0.5	4	

Proportion of materials per m^3:

Mix proportion = 1: 2: 4

cement = 178 kg

Sand / Quarry dust / Fly ash = 371 kg

Paper = 740 kg

water = As it required

- EXPERIMETAL WORK

After casting the bricks, they were analyzed for using as a brick. Various tests were carried out to check the properties of the bricks. And the results of that test were analyzed with the existing and standard results. The following tests were carried out to check the brick.

1. COMPRESSION TEST

This test only decides the strength of the brick. This test was carried out by a universal testing machine. This test was carried out on the 28th days from the date of casting. While testing the papercrete brick great care must be taken, because papercrete bricks never failed catastrophically, it just compressed like squeezing rubber. So load was applied up to full compression. When papercrete brick failed at the higher load, the structure was not fully collapsed. Only the outer faces cracked and peeled out.

Formula used:

Compressive Strength (N/mm^2) = Maximum load at failure in N / Avg. area of the bed faces in mm^2

2. WATER ABSORPTION TEST

Water Absorption Test is used to find out the water absorption ratio. Because the brick, which are absorbing more water cannot be used in water logging area or exterior walls which is open to sky. The bricks from all the proportion were tested.

3. WEIGHT OF BRICK

Lightweight bricks are also the important objective of this project. So, all the bricks were tested whether they are having less weight or not. All the bricks were weighed in a well conditioned electronic weighing machine.

4. COST ANALYSIS

In this project, cost was calculated for all proportions. And cost for production of 100 brick was calculated. From that, cost of one brick was calculated.

TABLE V: COST ANALYSIS

Mix No.	Mix proportions (by weight basis)							Total cost of	
	Cement	Egg shell	Fly Ash	Quarry dust	Sand	Paper	Admix -tures	100 bricks (Rs.)	One brick (Rs.)
M1	78	1.66	_	11.12	5.35	70.50	31.47	199.17	1.99
M2	78	_	2.14	11.12	_	70.50	31.47	193.23	1.93

M3	78	_	2.14	5.35	5.55	70.50	31.47	193.01	1.93
M4	78	3.32	0.53	2.78	5.35	70.50	31.47	191.95	1.91
M5	78	1.15	1.60	5.55	2.67	70.50	31.47	190.94	1.90
M6	78	1.66	1.07	5.35	5.55	70.50	31.47	193.6	1.93

RESULT AND DISCUSSION

1. COMPRESSION TEST

A brick that is used for construction should have compressive strength more than 3.5 N/mm^2. In these above 6 bricks, only 4 type of bricks got compressive strength more than 3.5 N/mm2. But, they are not suitable for load bearing walls. Because, papercrete bricks are having more elastic behaviour at failure. It compresses like rubber. So at heavy load, the bricks may compress. Due to this compression the roof may be collapsed. So these bricks are suitable only for non-load bearing partition walls. FA & QD mix proportions are having lesser compressive strength compare than FA & SD mix proportions and also M5 resist high compressive strength because of pozzolanic reactivity.

TABLE VII: AVERAGE COMPRESSIVE STRENGTH ON BRICK

Trial mix	Average Compressive Strength (N/mm^2)
M1	6.32
M2	4.74
M3	7.90
M4	2.77
M5	11.86
M6	3.52

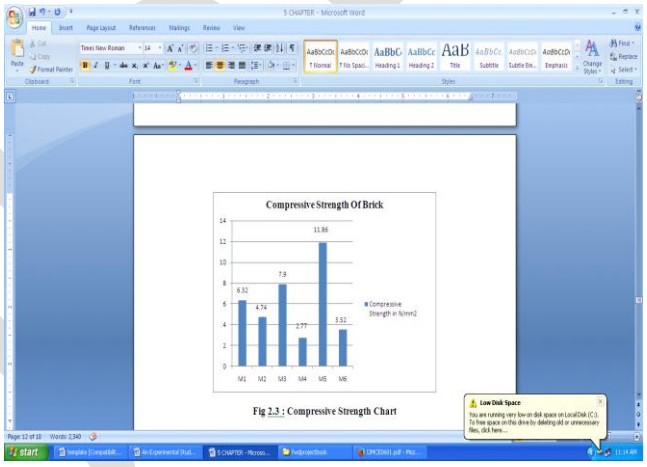

Fig 3: Compressive Strength Chart

2. WATER ABSORPTION TEST

As per standard, the bricks should not absorb water more than 20% of its weight, but from the table 3.4.2 results, bricks exceeded water absorption ratio more than 20%. In this, the mix that contains only paper and cement absorbs water more than its weight. And the mixes that were mixed in 1:2:4 ratio absorbed more water. So these bricks are not suitable for water logging and exterior walls. These bricks can be used for interior partition walls only.

TABLE VIII : % OF ABSORPTION WATER

Mix	Dry weight, W1 (Kg)	Wet weight, W2 (Kg)	Water absorption in (%)
M1	1.155	1.765	52.81
M2	1.197	1.896	58.40
M3	1.095	1.685	53.88
M4	1.165	1.975	69.53
M5	1.137	1.592	40.02
M6	1.225	1.997	63.02

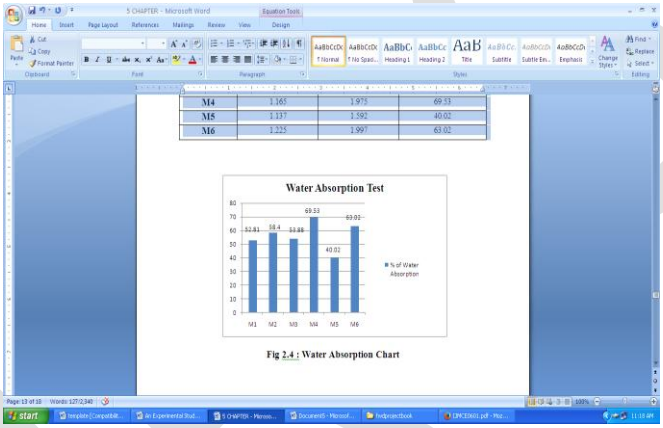

Fig.4 : Water Absorption Chart

3. WEIGHT OF BRICK

The ordinary conventional bricks weight varies from 30 to 35 N, but the papercrete bricks weight varies from 10 to 12 N. The maximum weight is less than 12N only. In this above proportion bricks are having 1/3 rd of the conventional brick weight only. Sand based bricks are having weight 2/5 th of conventional brick weight only. So this bricks are light weight and it will also reduce total cost of construction due to the reduction in dead load.

TABLE IX: WEIGHT OF BRICKS

Mix	Average weight (Kg)	Average weight (N)
M1	1.155	11.33
M2	1.197	11.74
M3	1.095	10.74
M4	1.165	11.43

M5	1.137	11.15
M6	1.225	12.02

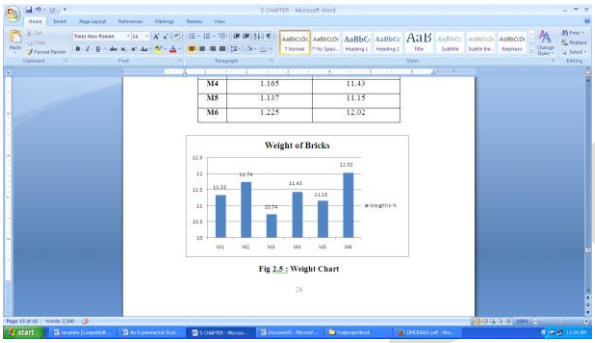

Fig.5: Weight Chart

4. COST ANALYSIS

In this cost analysis, M5 brick cost is only Rs.1.62 for 1 brick. But the rate of normal conventional clay brick varies from Rs.2.5 – Rs.3.5. So the rate of papercrete brick is varies from 45% to 84% of conventional brick. So, the total cost of the building will be reduced.

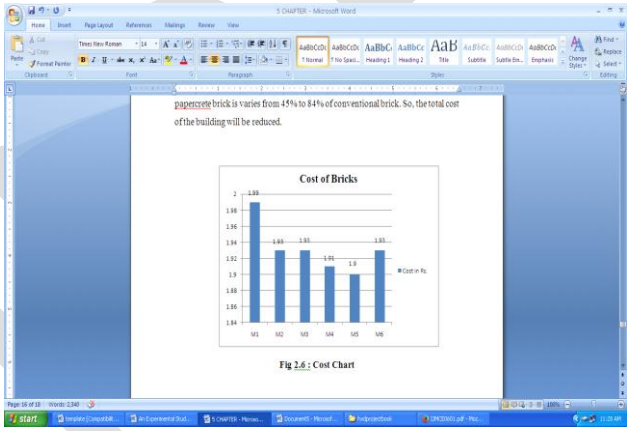

Fig.5: Cost of Bricks

REFERENCE

- B. Fuller, Fafitis and L. Santamaria, "Structural Properties of a New Material of Waste Paper", ASCE Civil Engineering, Vol. 76, No. 5, May 2006, pp. 72 – 77.
- Paki Turgut, Halili Murat Algin,"Limestone dust and wood sawdust as brick material", Journal of Building and Envi,Vol 42,February2007, pp301 – 319.
- Gordon Solberg, "Building With Papercrete & Paper Adobe: A Revolutionary New Way to Build Your Own Home for Next to Nothing" Second Edition- 2002.

- Topcu IB, Canbaz M, "Properties of concrete containing waste glass", Journal of Cement and Concrete Research, Vol 34, 2004, pp 267–274.
- Shayan A, "Value-added utilisation of waste glass in concrete", Journal of Cement and Concrete Research, Vol 34, 2004, pp 81–89.
- Shi C, Wu Y, Riefler C, Wang H, "Characteristic and puzzolanic reactivity of glass powders", Journal of Cement and Concrete Research, Vol 35, 2005, pp 987–993.
- Ronaldo S. Gallardo Mary Ann Q. Adajar, "Structural performance of concrete with paper sludge as fine aggregate practical replacement enhanced with admixtures"-Symposium on Infrastructure Development and the Environment 2006 was held on 7th and 8th October 2006 at university of the Philippines.
- Lex Terry, "Papercrete Construction"- Building Environment and Thermal Envelope Council (BETEC) Symposium was held on 13th to 16th October 2006 at the Northen New mexico Community College in EIRito.
- IS: 383-1970, "Specification for coarse and fine aggregates from natural sources for concrete", Bureau of Indian Standards. New Delhi.
- IS: 8112-1989, "Specification for 43grade Ordinary Portland Cement", Bureau of Indian Standards. New Delhi.
- Corinaldesi V, Gnappi G, Moriconi G, Montenero A, "Reuse of ground waste glass as aggregate for mortars", Journal of Waste Management, Vol 25, 2005, pp 197–201.
- IS: 1077-1992, "Common burnt clay building bricks – Specification", Bureau of Indian Standards. New Delhi.
- IS: 3495-1992 (Part 1 to 4), "Methods of Tests for Burnt Clay Bricks", Bureau of Indian Standards, Third Revision, New Delhi.