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Innovative Brick Manufacturing using Papercrete

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Abstract: *Based on nature review there are 3.04 trillion trees around the world and for the purpose of paper manufacturing around 4 billion trees are demolished. The non-renewable resources have been largely consumed by the construction industry. The waste papers produced are dumped in landfills and dumpsites. The intention of this research is to find out the weight, compressive strength, cost of brick by using waste papers (newspapers) in order to verify their suitability for use as a building construction material.In this investigation, industrial wastes like paper waste, flyash and Eggshell powder of three varying proportions are used as replacement for cement. The self-weight of bricks made by using paper pulp with cement and sand is approximately 50% lesser than the conventional bricks. As a result of the experimental investigation there is a considerable decrease in the dead weight of the structure.*

Keywords: Papercrete, fly ash, Weight, Compressive strength.

I. INTRODUCTION

Owing to the increasing population the increase in usage of building material has lead to increase in demand of materials. Due to the shortage of materials the conversion of wastes from industries as building materials has become a great challenge. Now days in developing countries the increasing environmental concern is due to the accumulation of unmanaged wastes. The recycling of such wastes as construction materials appears to be practical solution for effects of pollution and economic design of buildings.

According to a research, globally above 450 million tons of papers are produced each year. By the year 2020 paper, 500 million tons of paper and paperboard are produced each year. It has been stated that pulb and paper is the third largest pollutant. In recent year, paper and paperboard constitute a greater portion of many countries' municipal solid waste generation, about 55% or 48 million tons of paper ends up in landfill sites while some are incinerated. Using waste paper as a construction material is one of the exclusive recycle opportunity. A conventional brick 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

Jegatheeswaran et al. (2008) have used sand, cement, earth and waste materials like paper, rice husk ash of various proportions for the manufacturing of brick and a suitable proportion which gave more strength, less water absorbance and more eco friendly was found out.

Amarnath et al. (2014) have used Eggshell - poultry waste in a powder form which is rich in calcium with chemical composition similar to that of limestone. It has been used as a replacement of cement and the properties of concrete been identified. Application of eggshell waste instead of natural lime as a cement replacement in concrete shall have benefits like reduction in use of cement, conservation of natural lime and utilization of waste material.

Gumaste et al. (2007) analysed the properties of bricks masonry constructed with wire-cutbricks and table molded bricks with various types of mortar. It is observed that usage of lean mortar failed due to loss of bond. Demir et al (2005) utilized another waste material Kraft pulp production residues in clay bricks. It is observed that increase in amount of the waste have been integrated in clay bricks. The conventional bricks have been altered with various percentages ranging between 0 and 10 at an increasing frequency of 2.5% .All the prepared samples were ignited at 900°C with another group as a green raw Bricks (unfired). The required water content and drying shrinkage moves up with the increase in amount of Kraft pulp residue.

III. MATERIALS AND ITS PROPERTIES

CEMENT

Ordinary Portland Cement (OPC) conforming to IS8112 - 1989 of 43 grade has been utilized. In general Cement is manufactured by a process known as calcinations

during which the limestone is incinerated with some quantities of other materials which include clay in a kiln to about 1450°C. The property of cement is shown in Table 1.

Table.1. Specification of cement

Properties	Results obtained	Specifications based on IS: 8112 – 1989
Initial setting time	64 minutes	Not less than 30 minutes
Final setting time	269 minutes	Not more than 600 minutes
specific surface - Fineness (using Blaine's air permeability test)	412.915 m^2/kg	Minimum of 225 m^2/kg
Soundness of cement (by Le-chatlier method)	0.2 mm	Maximum of 10 mm
Cement mortar cubes Compressive strength 3^{rd} day 7^{th} day 28^{th} day	 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

SAND

For this study locally available river sand was utilised as fine aggregate. The properties of sand were determined by conducting tests as per IS: 2386 (Part- I). Fine Aggregate utilized possesses the following properties. 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.

Table.2 .Sieve Analysis of Fine Aggregate used in this study (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	90 - 100
2.36 mm	0.04	2.0	98.0	2.0	75 - 100
1.18 mm	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					

WATER

Water utilised in this study for mixing and curing of bricks was clean and free from foreign matters include oils, acids, alkalis, salts and organic materials or other substances since that 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 should be more than 6.

FLY ASH

Fly ash is a deposit or by product resulting from combustion of broken up coal or lignite in thermal power plants. Some varieties may have binding property and some may not have, depending upon the coal used. Fly ash is very fine comparable to cement, however some particles may have grain size less than 1 µm in equivalent diameter. The chemical ingredients of fly ash are shown in Table 3.

Table.3. Chemical Properties of Fly Ash

Components	Percentage (%)
Sio_2 - Silica	35-59
Fe_2O_3 - Iron	0.5-2
Al_2O_3 - Alumina	20-33
CaO – Calcium	5-16
MgO - Magnesium	1-5.5
So_3 - Sulphate	0.5-1.5
Incineration loss	1-2

EGG SHELL

The eggshells have a natural content of Calcium carbonate ($CaCO_3$). It gives hardness and strength. A good quality eggshell will have an average of 2.2 grams of calcium Carbonate as Calcium. The percentage Proportion of $CaCO_3$ in eggshell powder is shown in table 4.

Table.4.Weight percentage of $CaCO_3$ in Egg shell powder

Sample	% of $CaCO_3$
1	96.70%
2	98.39%
3	94.80%

QUARRY DUST

When boulders are broken into small pieces quarry dust is formed and it is a fine rock particles. It is grey in colour and it is like fine aggregate. As per IS-383-1987 the preliminary tests on quarry dust were conducted and its

specific gravity was found to be 1.94. Wet sieve analysis of quarry dust through a 90 µm IS sieve was found to be 77.6% and the respective bulking value of quarry dust was 34%.

WATER PROOFING POWDER

Waterproofing material in form of powder contains waterproofing additives which is then dispersed in static fine filler. It is an integral powder-waterproofing material used for hydro proofing of concrete and cement plasters, since it makes concrete more cohesive and reduces porosity. It results in improved water tightness and reduced water absorption. It satisfies the specification requirements of IS: 2645 – 1983.

SBR LATEX POLYMER

Nowadays Emulsion polymerized styrene - butadiene rubber (E-SBR) is one of the globally used polymers. The limitations of Natural rubber is its high molecular weight, low miscibility with low molecular weight resins, low polarity and low Ultra Violet, thermo-oxidative stability resulting in discoloration throughout the life span of a PSA product. Diffusive bonding supplies the strong interaction at the interface location.

PAPER

Paper is principally belongs to wood cellulose, where Cellulose is a natural polymer. The cellulose chain bristles with polar -OH groups. These groups create hydrogen bonds with -OH group on adjacent chains, and bundling the chain together. The chains also bond regularly in places to form hard and stable crystalline region that results the bundled chains even more stability and strength. The cellulose hydrogen bonds are shown in Figure 1.

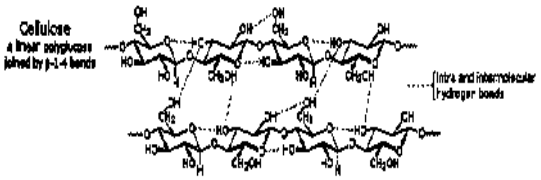


Fig 1. Cellulose hydrogen bonds

In this, a matrix is formed by fibrous and fibrils network, which finally coated with cement (OPC) used in the study. They cling together with the power of hydrogen bond when these networks of fibre and fibrils get dried. The strength is enhanced by coating this fibre with ordinary Portland cement. Although course paper has more in it than cellulose, raw cellulose has comparatively rough texture in nature. Clay and rice husk ash are added to enhance the smoothness of cellulose.

IV.EXPERIMENTAL INVESTIGATION

In this experimental investigation, manual mixing of materials was carried out. After mixing, it the composition was placed in the mold within 30 minutes. Hand molding method of Brick molding was employed. And it was carried out in ground itself as ground molded bricks. Since paper used in the study can hold water for long time, no extraordinary care was required for curing perspsective. The details of mixing

Table.5. Details of Mix Methodology

Mix No.	Mix proportions (by weight basis)						Water proofing powder & SBR latex polymer
	Cement	Egg shell	Fly Ash	Quarry dust	Sand	Paper	
Mix 1	1	0.5	_	1	0.5	4	20% (by the weight of Cement)
Mix 2	1	_	1	1	_	4	
Mix 3	1	_	1	0.5	0.5	4	

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. The average compressive strength of brick for various mix proportion is shown in Table 6.

Table.6.Average compressive strength on Brick

Trial mix	Average Compressive Strength (N/mm^2)
M1	6.32
M2	4.74
M3	7.90

Fig 2.Testing of Brick

WEIGHT

Manufacturing of lightweight bricks is also the significant aim of this study, so that Dead load coming over the foundation shall be minimised. Hence, all the bricks were tested and comparison with the weight of standard bricks was made. All the oven dried bricks were weighed using electronic weighing machine of accuracy 0.1 g. The weight of papercrete bricks are shown in Table 7. Figure 3 shows the Weight of Papercrete Brick belongs to Mix 2.

Table 7.Weight of Papercrete Bricks

Mix	Average weight (Kg)	Average weight (N)
Mix 1	1.155	11.33
Mix 2	1.197	11.74
Mix 3	1.095	10.74

Fig 3.Weight of Brick

V.COST ANALYSIS

Expenditure was calculated for all proportions of mix 1, 2 and 3. The total cost for production of 100 bricks was arrived. The Table 8 shows the cost of bricks.

Table 8.Cost of Bricks

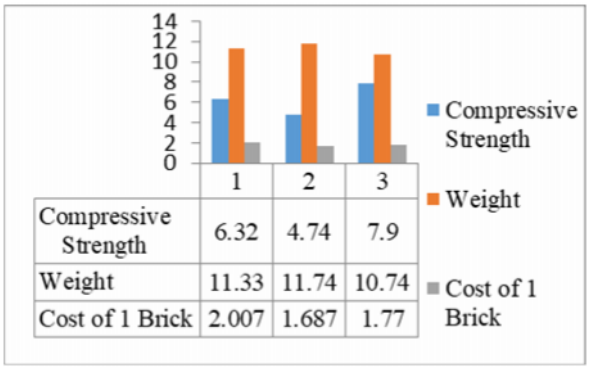
Mix No.	Mix proportions (by weight basis)							Total Cost	
	Cement	Egg shell	Fly Ash	Quarry dust	Sand	Paper	Admixtures	100 bricks (Rs.)	One brick (Rs.)
Mix 1	80.5	1.6	_	11	5	71	32	200	2.00
Mix 2	53.8	_	2	11	_	70	32	168	1.68
Mix 3	70.9	_	2	5	6	62	32	177	1.77

VI. RESULTS AND DISSCUSSION

The compressive strength of brick should be more than 3.5 N/mm^2. The strength of brick for all mix 1, 2 and 3 are greater than 3.5 N/mm^2.

The weight of conventional bricks varies between 30 and 35 N, whereas the papercrete bricks weight varies between 10 and 12 N respectively.

The cost/per brick of conventional clay brick lies between Rs.2.5 and Rs.3.5, but the cost of papercrete brick is 45% to 84% lesser than that of conventional brick.



	1	2	3
Compressive Strength	6.32	4.74	7.9
Weight	11.33	11.74	10.74
Cost of 1 Brick	2.007	1.687	1.77

VII.CONCLUSION

- These bricks can be used as filling materials in Framed Structures and these kinds of Papercrete bricks are not suitable for water sorting location and exterior walls.
- It can be used in interior location of structures.
- Because of lesser weight, usage of this kind of bricks in structures shall reduce the Dead load of buildings.
- The bricks cannot be used for load bearing walls because it absorbs more water. Further study may be engaged by using some admixtures for water absorption reduction.

REFERENCES

1. 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.
2. Paki Turgut, Halili Murat Algin,“Limestone dust and wood sawdust as brick material”, Journal of Building and Envi,Vol 42,February2007, pp301 – 319.
3. Gordon Solberg, “Building With Papercrete & Paper Adobe: A Revolutionary New Way to Build Your Own Home for Next to Nothing” Second Edition-2002.
4. Topcu IB, Canbaz M, “Properties of concrete containing waste glass”, Journal of Cement and Concrete Research, Vol 34, 2004, pp 267–274.
5. Shayan A, “Value-added utilisation of waste glass in concrete”, Journal of Cement and Concrete Research, Vol 34, 2004, pp 81–89.
6. 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.
7. 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.
8. IS: 383-1970, “Specification for coarse and fine aggregates from natural sources for concrete”, Bureau of Indian Standards. New Delhi.
9. IS: 8112-1989, “Specification for 43grade Ordinary Portland Cement”, Bureau of Indian Standards. New Delhi.
10. Corinaldesi V, Gnappi G, Moriconi G, Montenero A, “Reuse of land waste glass as aggregate for mortars”,

Journal of Waste Management, Vol 25, 2005, pp 197–201.

11. IS: 1077-1992, “Common burnt clay building bricks – Specification”, Bureau of Indian Standards. New Delhi.