MAPLE TREE PUBLISHING HOUSE

INTERNATIONAL RESEARCH JOURNAL OF MULTIDISCIPLINARY TECHNOVATION (IRJMT)

http://www.mapletreejournals.com/index.php/IRJMT
Received 09 September 2019 ISSN 2582-1040
Accepted 17 October 2019 2019; 1(6); 334-341
Published online 02 November 2019

Flyash Based Paper Slurry Building Bricks– an Experimental Approach

D.Jegatheeswaran [1,*], R. Malathy[1]

[1]*Department of Civil Engineering, Sona College of Technology, Salem, Tamil Nadu, India.*

**Corresponding author E-Mail ID: jegatheeswa@gmail.com*

Doi: https://doi.org/10.34256/irjmtcon44

ABSTRACT

This paper deals with the investigation carried out to study the Strength Properties of Papercrete Building Bricks and these results were compared with conventional bricks. The papercrete brick did not fully collapse even at ultimate load and it never failed catastrophically. Hence the outer faces got cracked and peeled out. From the observation of the compression test, it is inferred that the papercrete bricks are having less elastic and are less brittle. Water absorption test was carried out as per the guidelines given in ASTM C-642. After coated with an external coating agent, the percentage of water absorption of the papercrete bricks was nearly the same as the conventional bricks. Also young's modulus and poisson's ratio of coated papercrete bricks was determined.

Keywords: Papercrete, bricks, strength, water absorption, thermal conductivity, water proofing agent.

1. INTRODUCTION

Accumulation of unmanaged wastes especially in developing countries has resulted in an increasing environmental concern. Recycling of such wastes as building blocks 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 [22]. The high volume of brick earth offers a holistic solution to the problems of meeting the increasing demands in the future in a sustainable manner and at a reduced or no additional cost, and at the same time reducing the environmental impact of industries that are vital to economic development. As natural sources of aggregates are becoming exhausted, it turns out urgent to develop. The majority of abandoned paper waste is accumulated from the countries all over the world causes certain serious environmental problems. The potential use of paper waste for producing a low-cost and light weight composite brick as a building material [20]. These alternative bricks were made with papercrete. An experimental investigation has been carried out to study the strength parameters of papercrete brick and brick unit.

2. MATERIALS USED

Paper is the main ingredient of papercrete and so its properties depend on paper's microstructure. Wood fragments are thermo metrically or mechanically treated to dissolve the lignin binder and to free the cellulose fibbers. Paper is then made by pressing the pulp to remove excess water. Paper is an anisotropic material and the quality and strength of its fibers differ

depending on several factors. They are the type of wood, the percentage of recycled paper, the amount of water in the pulp, the way of pulping and the speed of drying. Table.1 shows the properties of dry paper.

Table.1 Properties of dry paper

Properties	Values
Weight	47 GSM
Thickness	0.06 mm
Moisture	7.5%
Bursting Strength	168 kPa
Tearing resistance	12.6 kg
Tensile Strength	1.13 kg
Porosity	475 mls/minute

The cement is obtained by burning of mixture of calcareous and argillaceous materials at very high temperature. The mixture of ingredients should be intimate and they should be in correct proportion. In this study, 43 grade Ordinary Portland Cement was used for the entire work. The physical properties of cement are satisfies the recommendation of IS-8112:1989.Flyash is generally obtained by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants and together with bottom ash removed from the bottom of the furnace. It is known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata. Its mineralogical composition, fine particle size and amorphous character is generally pozzolanic and in some cases also self cementitious [18]. Two classes of flyash are defined by ASTM C618: Class F flyash and Class C flyash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. In this study, flyash was collected from Metur thermal power plant. It is a Class C flyash (dryash). Paper is a fully water absorbable material. Hence to minimize the water absorption, water proofing admixtures were used as one of additives in papercrete mix. Generally the water proofing admixtures consists of two approaches, namely internal and external. In the study, internal and external water proofing admixtures are used by means of mix optimization

.

3. PREPARATION OF SPECIMEN

The papers which were collected could not be used directly. Before mixing with other ingredients, papers were converted into slurry form, known as pulp. First the pins, threads and other materials were removed. Then the papers were torn into small pieces and all the torn pieces of papers were immersed in water. The papers were kept in water for 3 to 5 days, and they soon degraded into a paste like form. After that period, the papers were taken out from water tank and shredded into little pieces. Using the small flavor machine, the shredded papers were converted into pulp. The various stages of pulp generation are shown in Fig.1. The paper pulp had residual water in itself, and it was not good enough for mixing the ingredients. So the required amount of water was added at the time of mixing. As per the mix optimization, cement, flyash, sand and paper were mixed with 1 : 0.5 : 1.5 : 4 proportion by weight basis. Internal water proof admixture added as 20% of cement weight to the mix at the time of mixing. Depending on the strength study, the papercrete was cast as brick (size: 230mm x 110mm x 70mm) and prism (size: 230mm x 230mm x 460mm, using papercrete bricks and 10mm thickness of 1:3 cement sand mortar).

a. Tearing the paper

b. Papers immersed in water

c. Small flavor machine

d. Paper pulp

Fig.1 Pulp Generation for papercrete bricks

3.1. PREPARATION OF BRICKS

The bricks were manufactured by brick pressing machine as shown in fig.2. All the ingredients were mixed as per mix proportion mechanically. After uniform mixing, the mixtures of ingredients were transported to a pressing unit by conveyor belt. The mixtures were poured into the brick mould and pressed with 10 N/mm^2 hydraulically. Immediately then, the bricks were taken out from the mould and kept in open air. After being dried in the air, i.e. on hearing the metallic sound when striking out the brick surface, the specimen was coated externally with water proofing admixture and it was dried 24 hours. Then the brick is ready for testing.

3.2. PAPERCRETE PRISMS

After casting the papercrete bricks, the prism was built with 1:3 cement sand mortar. First, two bricks were laid down and joints were filled with cement-sand mortar with 10 mm thickness. Over the cement sand mortar layer, another two bricks were laid opposite the base course, i.e. stretcher and header courses laid alternatively over the bricks. After casting the prism, the top and bottom faces are plastered with 10 mm thickness of 1:3 cement sand mortar. For the curing purpose, water was applied over the plastering surface by spraying.

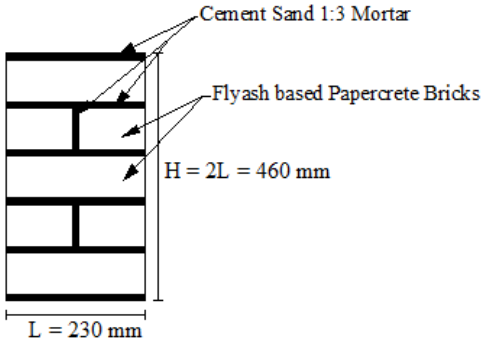


Fig.2 Dimensions of the papercrete prism

After the lapse of 28 days of curing, the prism was coated with water proofing admixture and it was dried for 24 hours. With the breadth of the prism considered as 'L', the height of the prism should reach '2L'. The dimension of the prism appears in Fig.2.Brick is one of the building elements used in the construction of a wall and the wall is a compression member.

4. EXPERIMENTAL PROGRAMME

4.1 Compression Test

So the use of good brick indicates how much amount of compressive strength it has. This test is carried out as per the guidelines given in IS 3495-1992. A compression test of flyash based papercrete brick was carried out by 100 tonne capacity UTM. Since the longitudinal deformation rises more and more, the plunger of the UTM comes out of the cylinder in a fast manner. To safeguard the machine, the machine movement of the plunger has to be rectified. Because of this, the ultimate load was determined based on the deformation capacity. When the brick failed at the higher load, the brick did not fully collapse because, papercrete bricks never failed catastrophically. It just compressed like squeezing rubber. So only the outer faces cracked and peeled out. From the inference of this test, the papercrete bricks are found to have elastic behaviour and less brittleness.

4.2 Water Absorption Test

This test is carried out as per the guidelines given in ASTM C-67. The specimens were dried in an oven at a temperature of 105ºC to a constant weight (W_1) and then immersed in water after cooling them to room temperature. The specimens were taken out of water at regular interval of time, wiped quickly with wet cloth and weighed (W_2) immediately, using an electronic balance. The percentage of water absorption at various time intervals and the average of three values were used in calculations.

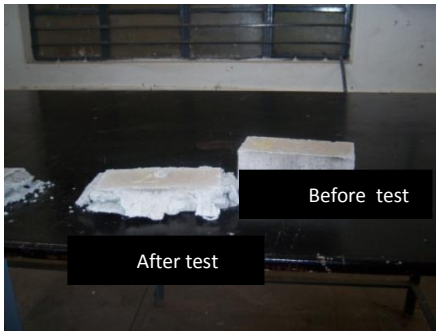
4.3 Behaviour of Masonry Prism

From the compression test on papercrete brick prism, the prism was subjected to vertical axial load by 100 tonne capacity Universal Testing Machine. The loading rate was 10 mm per minute. The four number of dial gauges (having 50 mm maximum and least count of 0.01mm) were fitted with four sides of the prism. The value of longitudinal deformation was recorded automatically by a digital UTM and lateral deformations with corresponding load values were also recorded. Based on the values, stress Vs strain and lateral Vs longitudinal deformation graphs were plotted.

5. RESULTS AND DISCUSSION

From the compression test, it could be seen that coated flyash based papercrete building bricks attained 4.20 N/mm^2.

(a) During the test



(b) Specimen before and after the test

The coated flyash based papercrete bricks resist the compressive strength more than 4.5% of the uncoated bricks and also they are 65% less than the conventional clay bricks. As per IS: 3495, the brick which has a compressive strength of more than 3.5N/mm2 was applicable for masonry work. But it is more suitable for non-load bearing wall, because of the ductile nature of the brick. Fig.8 and Fig.9 illustrate the behaviour and compressive strength of flyash based papercrete bricks.

Fig.8 Behaviour of flyash based papercrete brick on compression

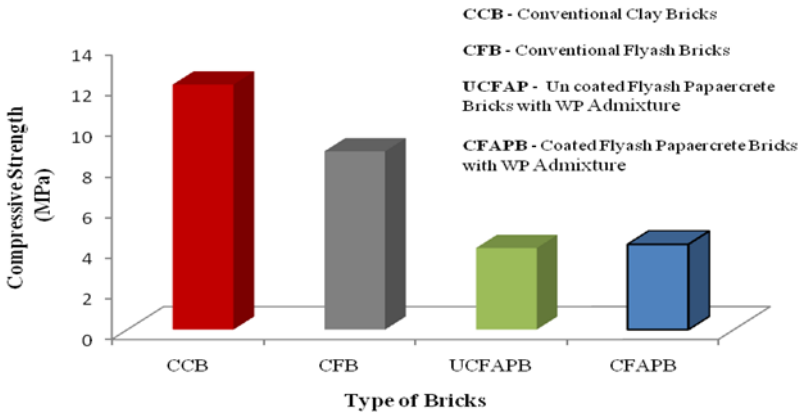


Fig.9 Compressive strength of flyash based papercrete brick

The percentage of water absorption of flyash based papercrete bricks without water proofing admixture was 40%. For coated flyash based papercrete bricks with water proofing admixture, the percentage of water absorption was 12.75%. It was less than 68% of uncoated flyash based papercrete bricks and it was more than 1.57% of conventional clay bricks. Fig.10 shows percentage of water absorption of various brick samples. The data collected from the compression test of flyash based papercrete prism were used to develop two graphs for each sample. The first is axial stress versus axial strain while the second, lateral strain versus longitudinal strain. E is derived from the slope of the stress-strain graph.

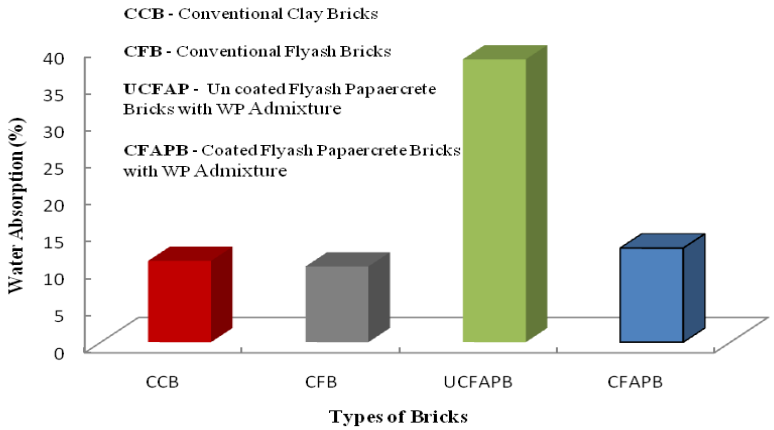


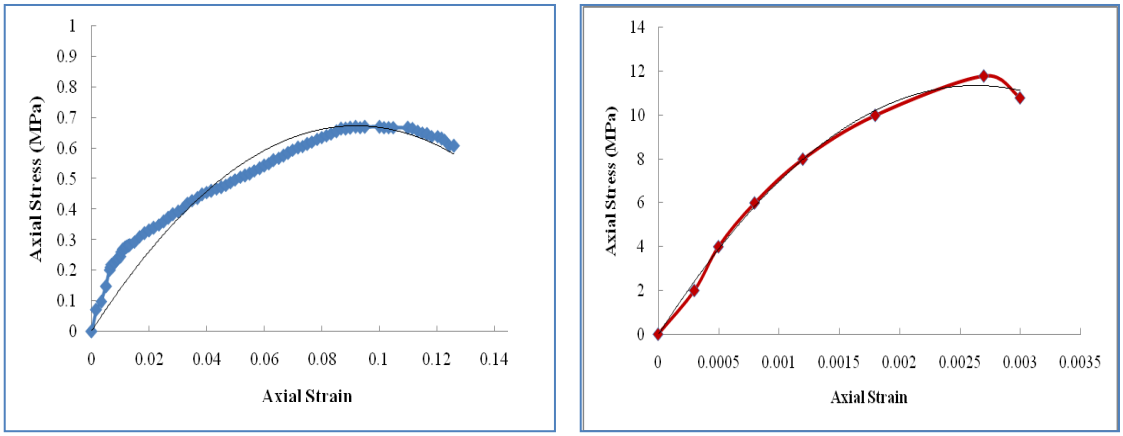
Fig. 10 Percentage of water absorption of brick samples

(A trend line was applied using Microsoft Excel in order to obtain the correct value of the slope of the curve). A working young's modulus is an approximate value obtained from the stress-strain curves, and it can be used as an index to characterize the compressive behaviour up to some given level of stress. In practice, the allowable compressive stress is expected to be at approximately this level.

(a) Conventional Brick Prism (b) Papercrete Brick Prism

Fig.11 Crack propagation of papercrete brick prism

The value of modulus of elasticity is calculated as the slope of tangent to the curve. Stress Vs strain relationship graphs of papercrete brick prism and conventional clay brick prism are shown in fig.12 (a) and Fig.12 (b) respectively.



(a) (b)

Fig.12 Stress-Strain curve for papercrete and conventional clay brick prism

Young's Modulus and Poisson's ratio of coated flyash papercrete brick prism was determined as 8.043 N/mm^2 and 0.471 respectively. These values are very low compared to the other building materials, but in literature support [7], the young's modulus of different type of papercrete brick units was in between 6.25 N/mm^2 and 14.4 N/mm^2. The lateral deformation is almost half (that is 0.47 times) of the longitudinal deformation. But Young's Modulus and Poisson's ratio of conventional clay brick prism were determined as 3.7x10^4 N/mm^2 and 0.321 respectively.

6. CONCLUDING REMARKS

From the test results, it is found that the papercrete bricks satisfy the limits specified by the code for conventional clay bricks. Coating of the papercrete bricks is absolutely necessary for durability purpose. It is observed that the coated and uncoated flyash based papercrete bricks are higher than 4 N/mm^2. As per IS code recommendation, the brick that contains minimum 3.5 N/mm^2 of compressive strength is acceptable for masonry work. So flyash based papercrete bricks are acceptable in building construction and also they are applicable only for framed structures because of the ductile nature. The uncoated bricks are used in making internal walls. Coated bricks are used anywhere. If the flyash based papercrete building bricks are used in seashore or chemical go-down building, necessary chemical resistant coating needs to be applied over the wall surface with desirable thickness.

7. REFERENCES

1. Ahmadi, B. and Al-Khaja, M. "Utilization of paper waste sludge in the building construction industry",Resources Conservation & Recyling Vol. 32, No. 2, pp. 105-113, 2001.
2. Algin Halil Murat and Turgut Paki, "Cotton and limestone powder wastes as brick material", Construction and Building Materials, Vol. 22, No. 6, pp. 1074-1080, 2008.
3. ASTM C618 – 08, "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolana for Use in Concrete", American Society for Testing and Materials, Retrieved 2008.
4. BS:4551-1980, "British Standard Methods of Testing Mortars, Screeds and Plasters", British Standards Institution, UK.
5. Dunster Andrew, M. "Paper Sludge and paper sludge ash in Portland cement manufacture" World conference on Integrayed WASTE Management, http://www.smartwaste.co.uk, 2007.
6. Farrell, M.O. and Wild, S. "A New Concrete incorporating Wastepaper Sludge Ash (WSA)", Proceedings of the International Conference - Innovations and Developments in Concrete Materials and Construction held at the University of Dundee, Scotland, UK on 9-11 September 2002, pp. 149-158, 2002.
7. Fuller, B.J., Fafitis, A. and Santamaria, J.L. "The Paper Alternative", ASCE Civil Engineering, Vol. 75, No. 5, pp. 72-77, 2006.
8. Gallardo Ronaldo, S. and Adajar Mary Ann, Q. "Structural Performance of Concrete with Paper Sludge as Fine Aggregates Partial Replacement Enhanced with Admixtures", Symposium on Infrastructure Development and the Environment 2006, University of the Philippines, Diliman, Quezon City, Philippines, 2006.
9. Ilker Bekir Topcu and Cenk Karakurt, "A Discussion of the paper – Physico-mechanical properties of aerated cement composites containing shredded rubber waste by Benazzouk, A., Douzane, O., Mezreb, K. and M.Queneudec", Cement and Concrete Composites, Vol. 29, No. 06, pp. 337-338, 2007.
10. IS:1077-1992, "Specifications for Clay Building Bricks", Bureau of Indian Standards, NewDelhi, India.
11. IS:1905-1987, "Code of practice for structural use of unreinforced masonry", Bureau of Indian Standards, New Delhi, India.
12. IS:2250-1981, "Indian Standard Code of Practice for Preparation and Use of Masonry Mortars", Bureau of Indian Standards, New Delhi, India.
13. IS:2116-1980, "Specifications for Sand for Masonry Mortars", Bureau of Indian Standards, New Delhi, India.
14. IS:3495 (Part 1 to 4)-1992, "Methods of Tests of Burnt Clay Bricks", Bureau of Indian Standards, New Delhi, India.
15. IS:8112-1989, "Specifications for 43 grade Ordinary Portland Cement", Bureau of Indian Standards, New Delhi, India.
16. Jesús, A.G. and Ochoa de Alda, "Feasibility of recycling pulp and paper mill sludge in the paper and board industries", Vol. 52, No. 7, pp. 965-972, 2008.
17. Joseph Khedari, Borisut Suttisonk, Naris Pratinthong and Jongjit Hirunlabh, "New lightweight composite construction materials with low thermal conductivity", Cement and Concrete Composites, Vol. 23, No. 01, pp. 65-70, 2001.

18. Siddique Rafat, "Special Structural Concretes", Galgotia Publications Pvt. Ltd., New Delhi, First Edition, 2000.
19. Solberg Gordon, "Building with Papercrete and Paper Adobe: A Revolutionary New Way to Build", Remedial Planet Communications Publishers, www.amazonbooks.com, 2006.
20. Subramani, T., Angappan, V., "Experimental Investigation of Papercrete Concrete", International Journal of Application or Innovation in Engineering & Management, Vol. 4, No. 5, pp 134-143, May 2015.
21. Tarun R. Naik, Yoon-moon Chun and Rudolph N. Kraus, "Concrete Containing Pulp and Paper Mill Residuals", Proceedings of International Conference on Fibre Composites, High Performance Concretes and Smart Materials, Chennai, pp. 515-525, 2004.
22. Turgut Paki and Algin Halil Murat, **"**Limestone dust and wood sawdust as brick material", Building and Environment, Vol. 42, No. 9, pp. 3399-3403, 2007.
23. Vegas, I., Urreta, J., Frias, M. and Garcia, R. "Freeze-thaw resistance of blended cements containing calcined paper sludge", Construction and Building Materials, Vol. 23, No. 13, pp. 2862-2868, 2009.
24. Weng Chin-Huang, Deng-Fong Lin and Pen-Chi Chiang, "Utilization of sludge as brick materials", Advances In Environmental Research, Vol. 7, No. 3, pp. 679-685, 2003.

Conflict of Interest

None of the authors have any conflicts of interest to declare.