

Experimental Investigation of Papercrete Clay Brick with GGBS

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Abstract: Papercrete is a mix of cement, paper pulp, sand or clay and water. It is an old concept of construction material which is discovered recently. The purpose of this investigation is to cast the papercrete brick using the clay, cement, paper pulp and water and investigate the properties of brick by introducing various percentages of GGBS for a replacement for cement. The mix proportion of the brick is chosen as 1:1.5:1.5 [cement: clay: paper pulp] by trial and error method because there is no proper code for mix proportion. The results are compared with the normal brick for the conclusion.

Keywords: Papercrete, GGBS, Compression Strength, Water Absorption.

I. INTRODUCTION

The papercrete is a new type of composite material which is an old concept but developed recently. The main constitution of papercrete is cement, sand, clay, paper pulp, and water. The papercrete is divided into different type according to various constitutions. They are fibrous concrete, Padope, and Fidope. The fibrous concrete main constitution is cement, paper pulp, and water. Cement is act as a binding material in fibrous concrete. One of the main advantages of fibrous concrete is that it is less weight compared to other types and weightless. On the other hand, earthen clay is a binding material for the padope and contains no cement. Its main constitution is clay, paper pulp, and water. It is also a lightweight compared to normal bricks. Fidope is like the padope except it has other fibrous compounds like sawdust, glass, coconut shell etc.,

Papercrete brick is an eco-friendly material which is low cost. The use of paper leads to recycling of waste paper which is dumped in disposal site. The paper pulp is prepared by using any kind of papers like cardboard, newspaper, magazines, Xerox paper, etc... Since there is a large demand for new composite material, papercrete brick will make some impact in growing construction field. The only problem in preparing papercrete is that there are no code provisions for proper mix proportions. Therefore code provisions and regulations are needed to prepare for future usage of papercrete.

Objectives of using the paper pulp in brick:

- To produce light weight composite material.
- To reduce the waste increment in dump yards
- To replace the conventional brick

II. MATERIALS USED

Material for papercrete preparation has been mentioned below,

A. *Cement:*

Cement is one of the binding materials used for this composite material. The cement is manufactured by using the silica, alumina, quicklime and small amount of gypsum and it is heated to form a clinker. Then the clinkers are crushed to obtain fine cement. There is a different type of cement are produced by varying the proportion of raw materials.

Different types of cement available in Indian market are

- Ordinary Portland cement (OPC)
- Portland Pozzolana Cement (PPC)
- High-early-strength cement (quick setting cement)

53 Grade Ordinary Portland cement is used as a binder in this project.

A. *Ground granulated blast furnace slag:*

The ground granulated blast furnace is a by-product of iron and steel making industries. It is obtained by quenching molten iron or steel slag from the blast furnace. It is a glassy material which is then dried and ground to fine material.

The main composition of GGBS is

- CaO (30-50%)
- SiO₂ (28-38%)

- Al_2O_3 (8-24%)
- MgO (1-18%)

The GGBS increase the compressive strength of the material. It is Light greyish white color.

B. Paper:

Paper is a fibrous or cellulose compound obtained from wood, grass, etc... Paper is a natural polymer compound contains a large number of -OH group to form a matrix. the mixing of wet paper to cement form a cement matrix which gives the extra strength to the material.

B. Water:

Water is one of the main ingredients for mixing of any raw materials. It gives the workability of materials. Water used is clean and clear and does not contain any other organic compounds. The pH of water is should be between 6-7.

C. Clay:

Clay is a naturally available fine soil contains clay minerals and traces metal oxides, quartz and organic matters. Clay are plastic in nature because of fine particle size and water content. Depending upon the soil content clay color varies from light grey to orange-red color.

The black soil has a clay content which is used in this experimental study. The clayed soil is also used as a binding material and gives a good texture to the brick. This is one of the main ingredient used in the conventional brick manufacturing.

III. EXPERIMENTAL PROCEDURES

A. Brick Manufacturing:

There are no clear procedures for manufacturing of this type of brick. Therefore procedure taken is for our own considerations. Equipment used is for our own convenience.

Therefore the mix ratio taken for manufacturing of brick is 1:1.5:1.5 (cement: clay: paper pulp) with replacement of 0,25,50,75,100 percentages of GGBS.

B. Mould Preparation:

The brick is cast by using the wooden mold having the dimension of 230mm length, 110mm wide and 90 mm depth. Shorter side has projected some length to act as a handle to easy removal of the mold after casting bricks. The mold must free from any gaps in joints and holes insides to get the uniform shape of the brick samples.

C. Paper Pulp Preparation:

The paper which is collected cannot be used directly. These steps are followed to get the paper pulp properly,

- Pins, tapes and any other non-paper materials are removed.
- Paper is shredded to form small pieces.
- Then small paper pieces are immersed in a bucket or tank containing 2/3 of the water.
- The paper is added small by small to complete wedding of each piece.
- Then the paper is allowed to rest for 3to 4 days.
- The wetted paper is mixed to form a uniform consistency.

Excess water in the paper pulp is squeezed before mixing.

D. Mixing of raw materials:

After collecting all the necessary materials mixing is done. For small-scale, manual mixing is done and for large-scale, mechanical mixing is done.

For mixing correct proportion of materials are batched as shown in table no: 1. Weight batching is preferred in this project. Therefore all materials are taken in kilogram units.

Table No : 1 Proportion for raw materials mixing

S.NO	Marking	Cement (kg)	Clay (kg)	Paper pulp(kg)	GGBS (in % of cement)
1	G0	1	1.5	1.5	0
2	G25	1	1.5	1.5	25
3	G50	1	1.5	1.5	50
4	G75	1	1.5	1.5	75
5	G100	1	1.5	1.5	100

The following procedure is used for mixing of materials,

- Safety equipment is needed to wear before mixing.
- Then mixing is done at the smooth and horizontal surface.
- First, dry ingredients like clay, cement, and GGBS is placed over the surface and mixed by using a shovel to form a uniform color
- Then wet paper pulp is placed in the mix and mixed thoroughly
- The water is added as per need and too easy removal of mold.

E. The casting of bricks:

After the mixing, brick is cast as fast as can because the initial setting time of cement is less than 30 minutes and workability of the mix is reduced. Therefore casting is done nearer to the mixing place.

The following steps are followed for the casting of bricks,

- The mold is placed in a uniform surface or table.
- The lump of the mix is taken and placed in a mold.
The excess mix is wipe out from the mold.
- Then the mold is removed and left to dry for 1 to 2 hour
- Then brick is dried in sunlight for 7 to 10 days.

After the drying, brick is ready for testing. In this project, sun-dried and Water curing of papercrete brick is done. For water cured papercrete brick, the sample is placed in water for 28 days after the initial drying. The testing of water cured brick is done after 2 to 3 days of drying in hot sunlight.

IV. RESULT AND DISCUSSION

After the samples are dried following test are done to examine the properties of the papercrete bricks.

A. The weight of samples:

The weight of the brick samples is shown in Table No 2.

Table No: 2 The weight of papercrete brick samples

S.NO	% GGBS	Wt of Sun Dried brick in kg	Wt of water cured brick in kg
1	0	2.267	2.370
2	25	2.231	2.340
3	50	2.197	2.314
4	75	2.167	2.257
5	100	2.122	2.165

The result shows that the weight of sun-dried papercrete brick is nearer to the 2 kg which is less than the conventional brick which weight 3 to 3.5 kg and water cured brick weight also less than conventional brick.

B. Compressive strength test:

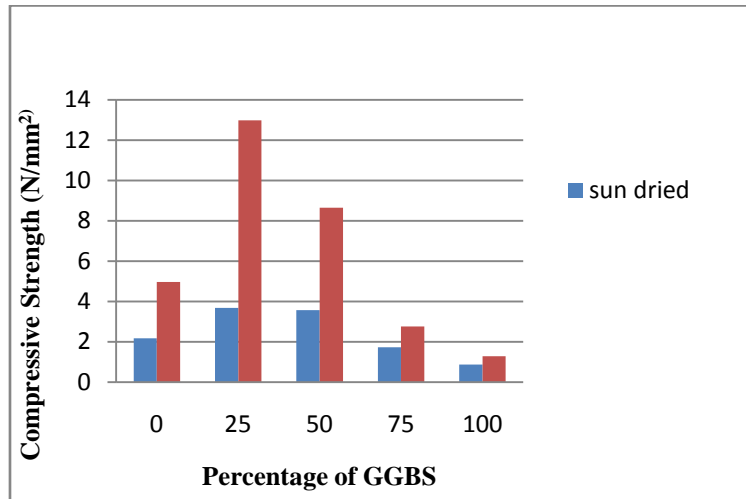
The compression testing machine used to determine the compressive strength of the papercrete brick. The test is carried out at 14 and 28 days from the casting of brick samples. While applying a load, papercrete brick did not break but compress like the rubber materials. The sides of the brick are peeled off. The compressive strength of sun-dried papercrete brick is shown in table no 3 and Water cured papercrete brick compressive strength is shown in table no 4. The graph No 1 is plotted to compare the compressive strength of sun-dried and water cured papercrete brick samples. Y-axis shows the compressive strength of brick at 28 days and X-axis shows the percentage of GGBS replaced for cement.

Table No: 3 The compressive strength of sun-dried Papercrete brick in N/mm²

S.NO	GGBS	14 days	28 days
1	0	2.17	2.17
2	25	3.68	3.68
3	50	3.57	3.57
4	75	1.73	1.73
5	100	0.87	0.87

Table No 4: The compressive strength of water cured papercrete bricks in N/mm²

S.NO	GGBS	14 days	28 days
1	0	3.54	4.97
2	25	10.39	12.98
3	50	6.35	8.65
4	75	2.17	2.76
5	100	1.13	1.29



Graph no 1: comparison between water cured & sun-dried papercrete bricks at 28 days

From the graph, we can conclude that compressive strength of water cured brick is higher than the sun-dried brick. The 25% to 50 % of GGBS replaced by cement shows the higher value of compressive strength



Fig 1: Papercrete brick after a compressive strength test

C. Water absorption test:

The water absorption test is done to find out the percentage water absorbed from the mortars. when papercrete absorbs more water from the cement mortar, it decreases the strength of mortar and poor binding between the bricks in the walls. The Table no 5 shows the percentage of water absorbed by papercrete brick samples. For water absorption test, dry weight of bricks is noted. Then papercrete bricks are immersed in the clean water for 24 hours. After that wet weight of papercrete brick is noted.

Table No: 5 % of Water absorption

S.No	% of GGBS in the sample	Sundried	Water cured
1	0	22.47	18.45
2	25	20.54	16.87
3	50	25.49	22.95
4	75	39.88	37.43
5	100	48.73	47.38

From the table, we can conclude that the water cured papercrete bricks absorbs less water than the sun-dried bricks.

D. Efflorescence test:

The efflorescence test is done to find any alkaline substances present in the brick. first, the edge of the brick is placed in 2.5 cm depth clean or distilled water. After absorption of water, it is dried in warm place and the process is repeated for 2 to 3 times and results are concluded by seeing the sample papercrete brick. When the white deposit cover 10% of the area it is said to be slight, for less than 50%, efflorescence is moderate and more than 50 %, efflorescence Said to be heavy. In papercrete, brick efflorescence is less for 0% and 25% of GGBS and moderate for 50% of GGBS and heavy efflorescence for 75% and 100% of GGBS. When papercrete brick of 50% and above percentage GGBS is immersed in water for 7 days, the resin-like substance is generated from the papercrete.

E. Structure examination test:

In this test papercrete brick is broken and its interior structure is examined. This test is done to find out the presence of any defects such as lumps, holes...the present I the papercrete brick.



Fig 2: Interior structure of papercrete brick

The broken papercrete is homogenous, free from any defects and dense packing of materials.

F. Fire resistance test :

The bricks used for the construction should be inflammable in open fire. Therefore fire resistance test is done to examine the fire resistance of bricks.

The following procedure is followed for fire resistance test,

- Any foreign materials present on the surfaces of the papercrete brick are cleaned.
- Then the papercrete brick is placed in the open flames for 30 to 60 minutes.
- Finally, brick is observed for the result.



Fig 3: Burning of papercrete brick



Fig 4: Interior of papercrete after burning

From the observation it is noted that outer surface of the papercrete is burnt and the interior is not burnt .when the bricks are placed in a fire for a long time it burns like the charcoal and paper present in papercrete is completely burnt. Therefore interior and exterior plasters need to provide for prevention from fire accidents.

G. Hardness test:

Hardness test is used to find that the papercrete brick is hard or not. The test is done by scratching the brick with sharp object or nail. The figure shows the hardness test result.



Fig 5: Hardness test for Papercrete having 25% of GGBS



Fig 6: Hardness test for papercrete having 75% of GGBS

From the result, we can conclude that the papercrete with 0% to 25% is sufficiently hard. Papercrete having GGBS percentage above 50 is not hard.

H. Soundness test:

The two brick having same ratio of materials are struck each other, it should produce clear ringing sound. Therefore from the test, 0%, 25% of GGBS papercrete brick produce clear ringing sound. 50% of GGBS papercrete produce irregular ringing sound. 75% and above the percentage of GGBS papercrete brick produce a dull sound.

V. CONCLUSION

Test results indicate that the papercrete brick with 25% of GGBS replaced with cement give almost as much result as the conventional brick of first class. Papercrete having 50% of GGBS replaced are like a second-class brick. Other percentage of papercrete brick having less strength and absorbs more water, therefore not suitable for construction purposed.

From the experimental study, we can conclude that,

- Papercrete brick having lesser weight compared to conventional bricks.
- These papercrete brick are suitable only for interior walls and non-load bearing structures.
- Papercrete bricks cannot be used in water logging area and exterior walls.
- These bricks are also used in the earthquake-prone area.
- These bricks are lightweight therefore decrease the dead load of the structures

The modified ratio of raw materials and adding of fibers will improve the properties of papercrete brick.

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