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Uniaxial Compression Loading Based Experimental Investigation on Papercrete Bricks

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ABSTRACT

The majority of abounded paper waste is accumulated from the countries all over the world that cause certain series environmental problems. The effective use of waste paper as a pulp can reduce the disposal problem which is one of the serious environmental health issues. In this paper a parametric experimental study is done to investigate the potential use of paper pulp to make bricks. The bricks are made of nominal mix that use portland cement, quarry dust, paper pulp and GGBS. The GGBS is used as trial mix of 0%, 20%, 30% and 50% respectively to investigate some properties by conducting the different tests on prepared bricks. In using paper pulp to make bricks, it reduces approximately 15% weight of the bricks that reduce the dead weight of the structure to a considerable amount. An experimental investigation has been carried out for the optimization of mix the papercrete bricks depending upon the compressive strength, unit weight and water absorption. This leads to a new design and a reduced building cost.

Keywords : Paper Waste, Bricks, Portland Cement, Compressive Strength

I. INTRODUCTION

In the fast growing construction industry a large amount of energy resources are suggested. The natural sources of aggregates are becoming exhausted which leads to relay on non-renewable energy source that turned out to be a recent development. In this regard a non-renewable energy source from the waste paper for this industry is proposed in this paper as a step towards sustainable development. Brick is a blend of earthen clay, sand and water. The key factor that adds value to brick is that it can be designed to withstand harshest environments significant role. Today global warming and environmental devastation leads to a manifest harms in recent years. The CO2 emission from construction sites becomes more because of cement usage. There is a large demand for building material that challenges the civil engineers to convert the industrial wastes to useful building and construction materials. Papercrete is a new composite material of waste paper is a replacement for Portland cement. Papercrete is a recently developed construction material which consists of re-pulped paper fiber with Portland cement.

II. METHODS AND MATERIAL

The proposed construction material consists of cement and fine aggregate. It captures carbon dioxide emissions by using waste as the main raw material. Papercrete bricks known by alternative names such as fibrous, padobe and fidobe. This experimental study investigates the potential use of waste paper for producing a low-cost and light weight composite brick as a building material. It has been used to build environmental friendly house. Papercrete is recommended to be an effective and sustainable material for the production of lightweight and fire-resistant hollow or solid bricks to be used to make partition walls of especially high-rise buildings. It is cost-effective, relies on locally available materials, but it is insect free, fire resistant, durable and great potential as a low carbon building material.

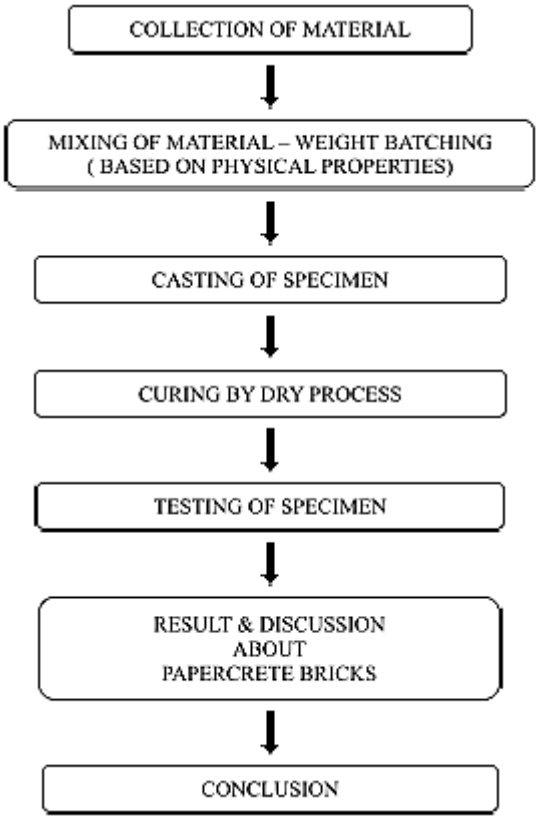

Figure 1. Proposed Papercrete Bricks Manufacturing Process

1. BRICK MIX DESIGN

1.1 OBJECTIVE

The desired properties of bricks can be obtained by adding the ingredients in a certain proportion. It is defined as the process of selecting suitable ingredients for bricks and to determine their relative quantities for producing the bricks of desired properties strength, durability and consistency, etc.., as economically as possible. The objective of mix design is to decide the properties of material, which will produce bricks with the required properties.

1.2 PAPERCRETE MIX RATIO

Mixing is done manually, when all the materials are ready. The mixing process of fibrous papercrete bricks and padobe bricks are different, and the processes are given below. The exact mix proportion is unknown, so trial proportions were used in this proposal. Table 1 shows the papercrete mix ratio.

Table 1. Papercrete mix ratio

Trial mix							
S.No	Specimen No.	Ingredients					
		Cement (kg)	Paper pulp (kg)	Quarry dust (kg)	CGBS % (weight of cement) (g)	Dr.Fixit LW+ (%)	Conplast WP90 powder (%)
1	S1	1	2	4	0%	10%	20%
2	S2	1	2	4	20%	10%	20%
3	S3	1	2	4	30%	10%	20%
4	S4	1	2	4	50%	10%	20%

2. CASTING OF BRICKS

The materials used were measured in kilogram before mixing. The non–water absorbing and smooth surface is chosen. The mixing place was selected nearer to the casting place. Water is sprinkled over that surface, the ingredients like Quarry dust/ GGBS are kept ready. Then the cement is added over the ingredient and is dry mixed with shovel thoroughly until uniform color is formed. The paper pulp in wet condition with less water is prepared. The already mixed cement and GGBS/Quarry dust is placed over the paper pulp and the water proofing compounds are added based on their quantity and mixed with shovel thoroughly still uniform mix. The mixer is then placed in three mould within 30 minutes by hand and on the ground. The mould was place over a ground. The extra or surplus mix is removed either by wooden strike or the metal strike or frame with wire and the casted papercrete bricks is dried for 14 days as shown in the figure.

Figure 2. Casting of papercrete bricks

3. EXPERIMENTAL INVESTIGATION

Various tests are carried out to check the properties of the casted bricks and the results of the tests were analyzed with the existing and standard results. The tests are i) Compressive Strength Test ii) Water Absorption Test iii) Hardness Test iv) Soundness Test v) Dimension Test
vi) Fire Test vii) Presence of Soluble Salts Test

3.1 COMPRESSION TEST

The most common of all tests on hardened bricks is the compressive strength test because of the intrinsic importance. The test is carried out by a Compression Testing Machine for their compressive strength after 7, 14 and 28 days curing from the date of casting. The bricks were tested in the testing machine by providing two of 6mm thick iron plates, one below and one above the brick to allow uniform distribution of load on the bricks. While testing the bricks great care must be taken because papercrete bricks never failed catastrophically, it just compressed like squeezing rubber. The load was applied up to half compression. When papercrete bricks failed at the higher load, the structure was not fully collapsed. Only the outer faces cracked and peeled out. The papercrete bricks are having elastic behavior and less brittleness. The compressive strength was calculated by this formula,

$$\text{Compression strength} = \frac{Maximum\ load\ at\ fail\ (N)}{Area\ of\ specimen\ (mm2)}$$

Table 2. Comparison test result of papercrete bricks

Specimen No	% of GGBS	Compressive strength (N/mm²)		
		7 days	14 days	28 days
S1	0%	1.95	2.48	3.26
S2	20%	2.7	3.35	4.78
S3	30%	3.55	4.10	6.16
S4	50%	5.08	6.06	8.7

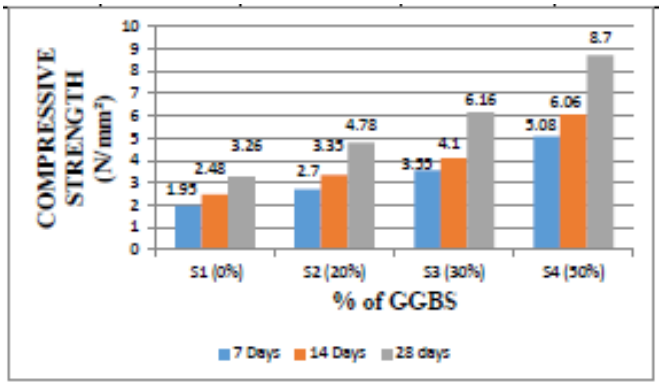

Figure 3. Graph shows comparison test of papercrete bricks

3. 2 WATER ABSORPTION TEST

The procedure for Water absorption test for papercrete bricks is carried out as per IS 3495 – Part 2. The bricks are dried in the ventilated oven at a temperature of 105^0C to 115^0C till it attains substantially constant weight. Cool the specimen to room temperature and obtain its weight (W1) specimen too warm to touch is not used. The dried bricks are immersed in clean water at a temperature of 27^0C+2^0C for 24 hours. Remove the specimen and swipe out any traces of water with damp cloth and weigh the specimen.

$$\%\ \text{age of water absorption} = \frac{W2-W1}{W1} \text{ x } 100$$

Where,
W1 = Weight of the dry brick
W2 = Weight of the brick after 24 hours immersion in water

Water absorption test result for different proportion

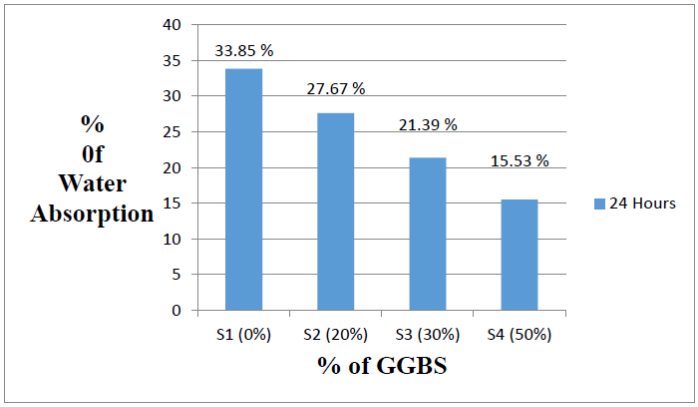

Figure 4. Graph shows Water Absorption Test for different proportion

3. 3 HARDNESS TEST

A scratch with finger nail is made on bricks surface. The test is carried out for all the three proportions of brick. A very light impression is left on the fibrous concrete brick surface. The test result shows that fibrous concrete bricks are sufficiently hard.

3. 4 SOUNDNESS TEST

Two bricks of same proportion were taken and they were struck with each other. The bricks were not broken and a clear ringing sound is heard. So the bricks are good.

3. 5 DIMENSION TEST

The bricks are closely inspected for standard shape and its shape should be truly rectangular with sharp edges. Ten bricks of standard size (220mm × 110 mm × 80mm) are randomly selected and stacked length-wise, along the width and along the height.

For a good quality brick, the results should be within the following permissible limits:

Length : 3680mm to 3920mm
Width : 1740mm to 1860mm
Height : 1740mm to 1860 mm

3. 6 FIRE TEST

A brick which is used for construction is subjected to flame. The brick was wiped with cloths and all the foreign matters were removed. Then the flammable sticks were fired. After that, the bricks were held on the flame for fifteen minutes. After fifteen minutes fixing was stopped and the bricks were observed. From the above test, it was observed that the fibrous concrete bricks did not burn with an open flame. They smoldered like charcoal. But these brick would be reduced to ashes after burning several hours. Properly wired places never cause fire. If we apply the plaster without any hole or leakage on the bricks, it won't burn or smolder inside because of lack of oxygen for burning.

3. 7 PRESENCE OF SOLUBLE SALTS

The soluble salts present in bricks will cause efflorescence on the surface of bricks. To find out the presence of soluble salts in a brick, this test was carried out. In this test fibrous concrete brick were immersed in water for 24 hours. Then the bricks were taken out and allowed to dry under shade. It was observed that there is no any grey or white deposit on the bricks surface. It results that the bricks are free from soluble salts.

III. RESULTS AND DISCUSSION

The proposed manufacturing process the final product was found with a maximum compressive strength that attained when the percentage of GGBS was 50% respectively and their compressive strength up to 8.8 N/mm2. The water absorption capacity of these papercrete bricks is relatively lower compared with ordinary clay bricks. Three sides of bricks are in smooth finishing. Top surface of the block had a good texture design. This method of manufacturing process reduces the investment cost as capital. Some of the challenges of the manufactured brick was handling of these bricks while transportation should be careful otherwise, the texture surface will be damaged. This bricks made with cement content, which leads to hydration, which evolves more heat from masonry. Most of the work is done by man power. The improper cleanness of moulds & careless remolding situations will damage or do not provide good finishing. It cannot be used in load bearing structure.

Table 3. Cost of material (Rs/Kg)

S.No	Material	Rate (Rs/ kg)
1	Cement	8.00
2	Quarry dust	0.30
3	GGBS	3.00
4	Paper	3.50
5	CONPLASS WP90	1.00

Table 4. Comparisons of papercrete bricks with conventional clay bricks

Description	Clay bricks	Papercrete bricks
Size in mm	215x100x70	220x110x80
Volume in mm^3	1505000	1936000
No of bricks in I cum masonry without mortar joints	664	517
Density in kg/m^3	1600	1780
Cost in INR per brick	6.50	5.00
Compressive strength (N/mm^2)	7.4	8.8
Water absorption	20% to 25%	10% to 20%
Efflorescence	It may be occur depends on soil	Nil
Colour	Standard as Red	Any colour

Texture	Plain	Various designed textures applicable
Finishing	Smooth	Smooth
Size	Standard	Standard

IV. CONCLUSION

In this paper the experimental results for the properties of Papercrete bricks under uniaxial compression loading is presented. From this Investigation the following conclusions were observed. The Papercrete brick consists of recycled materials and therefore it is cost effective when compared to conventional bricks, can easily be molded into any shape, are much easier to lift to any desired height and very good surface finish, has good fire resistance, are good sound absorbent, the weight of this bricks is 15 -20% lesser than conventional clay brick. Due to less weight of these bricks, the total dead load of the building will be reduced, are more suitable for non-load bearing walls only. Since, these bricks are relatively light weight and more flexible, these bricks are potentially ideal material for earthquake prone areas. These bricks are not suitable for water logging and external walls. It can be used in inner partition walls. These bricks are termite proof. The waste materials used will reduce the landfills and pollution. By using the Papercrete brick in a building, total cost will be reduced from 20% to 25%.

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