



# Experimental Study On Papercrete Preparation And Characteristics

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**Abstract** - In this article the experimental study of construction method of walling is done using Papercrete Technology is done and compared its Strength and durability of the structure, stability, safety and mental satisfaction are factors that assume top priority during cost reduction. It is found that about 26.11% of the construction cost can be saved for walling alone. This proves that using low-cost building technologies is a cost-effective construction approach for the industry. Papercrete is a sustainable building material due to reduced amount of cement usage and recycled paper being put to good use. The high volume of concrete offers a holistic solution to the problem of meeting the increasing demands for concrete 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 development. The majority of abandoned paper waste is accumulated from the countries all over the world causes certain series environmental problems. This project deals a parametric experimental study which investigates the potential use of paper waste for producing a low-cost and light weight concrete as a building material. An experimental investigation has been carried out to optimization of mix for papercrete depending upon the compressive strength and flexural strength.

**Keywords:** papercrete, paper pulp, walling construction, compressive strength.

## 1. INTRODUCTION

Low Cost building technology is a new concept which deals with effective budgeting and following of techniques which help in reducing the cost construction through the use of locally available materials along with improved skills and technology without sacrificing the strength, performance and life of the structure. There is huge misconception that low-cost housing is suitable for only substandard works and they are constructed by utilizing cheap building materials of low quality. The fact is that low cost building is done by proper management of resources. Economy is also achieved by postponing finishing works or implementing them in phases. Here for wall construction as a super structure, we use papercrete as our main material. Papercrete - a portmanteau of paper and concrete - is essentially an industrial-strength papier mâché drawing on paper or cardboard, sand, chips and Portland cement or clay. It can be fashioned in blocks, sheets or other moulded forms and used as a building material.

Shelter is the most essential element of any life style. In the countries like India, Africa, Australia, millions of people are homeless. This is because of high cost of building materials like steel bar, cement. Papercrete concrete is one of the most important building materials which can be manufactured by using waste paper and it is inexpensive too. Papercrete is recently developed construction material which contains of repulped paper fiber with Portland cement or clay and sand. This type of material is considered environmentally friendly material. 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 the environment as well as maintaining the material. In the construction industry, building technology is heading towards an entirely new era because of the usage of industrial wastes in various forms of building material production.

## **2. LITERATURE REVIEW**

Manuel (2002) has studied that physical characteristic of papercrete are mainly depending upon the relative amount of sand and Portland cement used.

Fuller (2006) show the conducted research to determine whether or not papercrete has suitable mechanical and physical properties to be used as construction material for homes. The parameters that he studied are the young's modulus (E), thermal conductivity (K), thermal resistance (R), bond characteristics, and creep behavior.

Dunster (2007) shows addition of 20% calcined paper sludge with cement paste accelerate setting time by 60 minutes, but results in reduction of workability.

H. Yun et al (2010) has found that density of papercrete was decreased when the replacement of waste paper increased. When paper replacement ratio was 5%, density was measured  $1.88\text{g/cm}^3$ , and it was reduced to 15% and 22%, respectively by increasing paper ratio 10% and 15%. The shrinkage of papercrete was increased according to increase of paper-cement replacement ratio.

Suganya (2012) states that papercrete bricks are relatively light weight, good sound absorbent and more flexible but it has high percentage of water absorption than conventional bricks. It can be easily cut into desirable shape. And also, it does not expand or contract due to surround environment.

J.N Akhtar et al (2011) They computed six different mix proportions by utilizing the Paper pulp and industrial by products like Fly ash, Rice husk ash. And also, due to the addition of paper pulp the bricks have low thermal conductivity, and it reduces the energy requirement for temperature control. While using paper pulp to make bricks, it will reduce approximately 50% of weight of the brick. Therefore, these bricks will reduce the dead weight of the structure to considerable amount. So, it changes our design and building as economical one.

Akinwumi et al (2014) has found the water absorption and fire resistance of papercrete to be high and increased with increasing waste paper content while the bulk density and compressive strength of papercrete were low and decreased with increasing waste paper content. Papercrete

was recommended to be an effective and sustainable material for the production of lightweight and fire-resistant hollow or solid blocks to be used to make partition walls of especially high-rise buildings. Mix proportions were recommended for production of hollow and solid blocks using papercrete.

### III MATERIALS AND METHODOLOGY

#### A. Preparation of Paperpulp

The papers, which were collected, cannot be used directly. It should be made into paper pulp before mixing with other ingredients. The following are the steps involved in the generation of pulp. First the pins, threads and other materials in the papers were removed and then the papers were teared into small pieces of papers. Then, a 200 L water tank was taken. And 2/3<sup>rd</sup> of it was filled with water. Then the small pieces of paper were immersed in the water tank. The paper pieces were immersed individually not in a bulky manner in order to make the pieces completely wet. Before immersing it into the water, the papers were weighed. The papers were kept in the tank for 2 to 3 days otherwise until the papers degrade into a paste like form. Then the paper was taken out from water and taken to the mixer machine to make it as a paper pulp.



Fig. 1 (a)



Fig. 2 (b)



Fig. 3 (c)



Fig. 4. (d)

Fig. 5 (a) to (d). Preparation of Paper pulp

### B. Papercrete

Papercrete is essentially a type of industrial strength paper maché made with paper and cardboard, sand and Portland cement. There are many varieties of Papercrete possible. Essentially, the constituents when mixed in different proportions result in Papercrete of varying properties. The basic constituents of Papercrete are:

- Paper: usually waste paper such as used newsprint or cardboard.
- Aggregate – coarse aggregate or fine aggregate such as sand may be used depending in the desired strength of the Paper Crete.
- Cement: it is used as a binder and used to provide strength and rigidity to the Paper Crete.
- Water

The method of making Papercrete is very simple. The dry ingredients are mixed with water in a mixer to form slurry. The slurry is cast into blocks or panels and allowed to dry in the sun. When it hardens up, papercrete is lightweight (its 80 percent air), an excellent insulator, holds its shape even when wet, and is remarkably strong. And, since it contains paper fibers, it has considerable tensile strength as well as compressive strength (Solberg, 2000). Papercrete is suitable for making low-cost homes with limited longevity and durability. It is also suitable for making community rooms, sale booths, storage rooms and dwellings for livestock. Papercrete can also be used as a plaster. It can be sprayed on walls to give them good sound and heat insulating properties.

**TABLE I PROPERTIES OF PAPERCRETE**

Properties	Values
Specific gravity	2.60
Colour	grey
Density	1.20

Moisture Content	6.28%
Initial Setting Time	195 min
Final Setting Time	330 min
Soundness	<10 mm

#### C. Soundness test

In this test, two bricks which are of the same proportion were taken and they were struck with each other. The bricks did not break and a clear ringing sound was produced which means that the bricks are good.

#### D. Structure test

In this test, a brick is broken and the structure of the broken brick was closely observed. If there are any defects like holes, lumps, etc., then the bricks are not of good quality.

#### E. Hardness test

In this test, a scratch was made on brick surfaces. This test was carried out for all the three proportions of brick. While the scratch was made with the help of finger nail on the bricks, very light impression was found on the surface of the fibrous concrete brick. So this test results that fibrous concrete bricks are sufficiently hard.

#### F. Nailing

When compared to conventional bricks, fibrous concrete bricks are less hard. So, in order to find out whether the brick can hold the nail or not, this test was carried out. Two specimens of bricks were taken. Out of the two bricks, a nail was hammered on the surface of one brick and a screw is also screwed on the other brick. The fibrous concrete brick could not hold nails but screws worked well and hold a considerable weight. So, the screws are the anchors of choice for fibrous concrete bricks.

#### G. Cutting and Glue

The labours could not able to cut the bricks exactly what they need. But fibrous concrete bricks can be cut into exactly two pieces by using conventional saw blades. So, we can get any shape and size of fibrous concrete brick. Many cut bricks are wasted in now a day. But if we apply a sufficient amount of glue on the bottom piece, the two fibrous concrete can be hold together and hence will not come apart.

#### H. Fire

A brick which is used for construction should not be flammable in open flame, so this test was carried out for the bricks. This test was carried out only for fibrous concrete bricks but not for padobe bricks for padobe bricks were already heated in kiln at high temperature so, it won't burn. The following are the steps involved in this test:

- First, the brick was wiped with cloth to remove all the foreign matters.
- Then some of the flammable sticks were fired. After that, the bricks were held on the flame for five minutes.
- After five minutes firing was stopped and the bricks were observed

## I. Specimen preparation

### (i) Batching:

Batching is the process in which the quantity or proportion of materials like cement, aggregates, water, etc. are measured on the basis of either mass or volume to prepare the paperconcrete mix. There are two types batching. They are as follows,

- Volume batching
- Weight batching

**Volume Batching of Concrete:** Volume batching of concrete is accomplished with the use of measurement boxes, locally named "farmas or gauge boxes". Concrete components like aggregates (Kapachi +Sand) and cement is calculated with farmas or gauge boxes and proper precaution should be maintained to ensure that the farmas or gauge boxes are filled excessively. To calculate the quantity of water, the water meter should be utilized when batching or use cans of water contain fixed volume. **Weight Batching of Concrete:** Weight batching of concrete is accomplished with the use of a weigh batch or the weighing system on the batching plant. On big projects, automatic batching plants are set up to facilitate optimizing quality and uniformity.

Water is very vital material and therefore, maximum water should be used for batching. If the quantity of water is less, the functionality of concrete will be hampered whereas surplus water will minimize the strength of concrete. Water should be computed perfectly in litres.

In our project, we measured the ingredients on the basis of volume batching, because we are adding 50% of dried paper pulp instead of chips as coarse aggregate. Here paper is a light weight material so paper cannot be equalized to chips by weighing.



Fig. 2 (a)



Fig. 2. (b)



Fig. 2. (c)



Fig. 2. (d)

Fig. 2. (a) to (d) Batching of the specimen.

#### (ii) Mixing

Mixing papercrete is simply defined as the "complete blending of the materials which are required for the production of a homogeneous papercrete". This can vary from hand to machine mixing. Here we are using hand mix method for mixing of papercrete blocks.



Fig. 3. (a)



Fig. 3. (b)



Fig. 3. (c)



Fig. 3. (d)

Fig. 3. (a) to (d) Mixing of the papercrete.

### (iii) Casting

The ingredients like paper pulp, cement, chips, water and admixture are taken in proper proportions as calculated in mix design and are mixed using a machine. The mixture is then casted using hydraulic concrete block making machine. It is then let to dry.



Fig. 4. (a)





Fig. 4. (b)



Fig. 4. (c)



Fig. 4. (d)



Fig. 4. (e)



Fig. 4. (f)

Fig. 4. (a) to (f) Casting process.

#### (iv) Curing

The best way to cure papercrete is to simply allow it to dry out naturally overtime, with as much air circulation around it possible. So, we have followed the method of dry curing for curing papercrete.



Fig. 5. Curing of the Paercrete.

### IV. RESULTS AND DISCUSSIONS

#### A. Compression test

Compression tests are used to determine a material's behavior under applied crushing loads, and are typically conducted by applying compressive pressure to a test specimen (usually of either a cuboid or cylindrical geometry) using platens or specialized fixtures on a universal testing machine.



Fig. 6. (a)



Fig. 6. (b)



Fig. 6. (c)



Fig. 6. (d)

Fig. 6. (a) to (d). Compression tests.

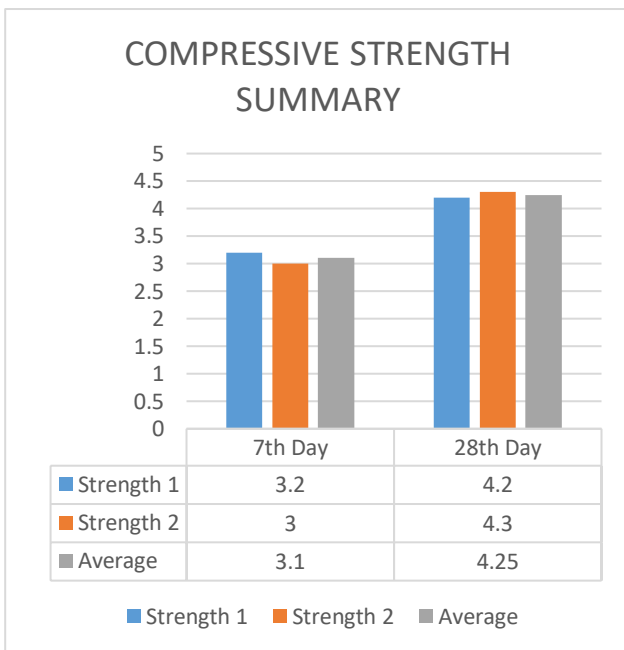


Fig. 7. Compressive strength summary

TABLE III COMPRESSIVE STRENGTH OF THE SPECIMENS

Specimen ID	Testing Date	Age of Testing	Size of Specimen(mm)			Weight (kg)	Density (kg/m <sup>3</sup> )	Load (kn)	Strength (mpa)	Average (mpa)	Remarks
			L	W	H						
1	22-03-2021	7	400	150	200	18.91	1816	192.6	3.2		
2	22-03-2021	7	400	150	200	18.9	1810	180.2	3.0	3.1	
3	13-04-2021	28	400	150	200	18.97	1816	252	4.2		
4	13-04-2021	28	400	150	200	18.96	1810	258	4.3	4.25	

#### B. Calculation of cementitious Material content

- Calculating cementitious material from the water cement ratio and the quantity of water per cu.m (water content)
- Check it from durability requirement.
- Select higher value
- The maximum as per IS 456

#### C. Selection of Water cement ratio

- For the same water cement ratio, the compressive strength may differ according to different cement, supplementary cementitious materials, aggregate size, grading, shape and surface texture
- Preliminary w/c may be selected from established relationship between w/c ratio and compressive strength.
- Alternatively, w/c ratio may be selected from table 5 of IS: 456 for respective exposure condition.

#### D. Applications of papercrete blocks

They are extensively used in home construction. In addition, it is used as sound and heat insulators. Their various shapes to decorate houses, flower pots. A large number of shapes are used to generate variety of constructions. As it is lightweight it can be used in various applications.

- They can be mould into any different shapes to decorate houses, flowerpots, etc.
- Can be used as sound proofing material.
- It is less catastrophic than materials like concrete so they can be used in high rise buildings in seismic zones.
- They can be also used in simple furniture in interiors as it provides aesthetic and opportunity for diverse designs. Literature illustrates its uses for partition walls, and façade material where benefit of dead load reduction of the structure is obtained.
- It can be used in interiors as it provides aesthetics and opportunity for diverse designs.
- High rise buildings in seismic zone can use papercrete as it is less catastrophic than other materials like concrete but due to limitations in some other properties such as behavior towards fire, durability concerns, biodegradability etc. it requires a significant amount of research for justifying its applications.

## E. Advantages

- They are light weighted but strong: Unlike concrete or adobe, papercrete blocks are lightweight, less than a third of the weight of a comparably-sized adobe brick. It is strong enough to hold up the load of roof on “low height” buildings.
- Easy to use: It is quick, easy to make and durable as well as fairly inexpensive and while most municipalities would not recognise it as an acceptable building material.
- Low cost: Papercrete is suitable for making low-cost homes with limited longevity and durability. They are remarkably inexpensive, since all the ingredients except for the cement are available for free or nearly free. They can be easily made by everyone as it has basic constituents.
- they are environmentally friendly: By the term environmentally friendly, it simply means having a lifestyle that are better for the environment. By using paper in buildings, we can significantly decrease amount of paper landing in the landfills. Using the concept of recycling of waste materials, papercrete is not only reducing the amount of cement using but also making it environmentally friendly.
- They provide good insulation since the raw material of paper contains a lot of fiber cellulose. Unlike those of concrete where heat from the sun heats the wall up and the concrete allow that heat to pass all the way through and radiate into the interior of the house.

## V. SUMMARY AND CONCLUSION

This study was conducted with an aim to learn the small-scale preparation of papercrete blocks, its design and construction skills and also had a focus on the assessment of the properties of this building blocks. The study recognized papercrete as a sustainable building material and emphasized on more research towards its performance parameters. The manufacturing, processing and construction techniques are still not developed enough to facilitate its use and this requires extensive amount of research. Papercrete can be developed as a material which is suitable for low-cost housing and temporary shelters and offices and can help reduce carbon footprint. It is thus evident that it can be looked upon as a sustainable building material and has a promising future. The study recognized papercrete as a sustainable building material and emphasized on more research towards its performance parameters. Papercrete bricks are suitable for non-load bearing walls only i.e., buildings made from this could be only of one storey. The weight of this brick is 1/3rd to 2/5th lesser than conventional clay brick. These bricks are not suitable for water logging and external walls. It can be used in inner partition walls as they are water absorbent. Due to less weight of these bricks, the total dead load of the building will be reduced. Since, these bricks are relatively light weight and more flexible, they have now become an ideal building material for earthquake prone areas. Papercrete can be developed as a material which is suitable for low-cost housing and temporary shelters and offices and can help reduce carbon footprint. But the papercrete should have the following characteristics.

- Affordable price

- Eco friendly
- Thermal insulation
- Less weight
- Less water absorption (when dry curing)

#### **CODE BOOKS USED:**

- IS:269-1989 Specification for Ordinary Portland Cement,33 grade.
- IS:383-1970 Specification for Coarse Aggregate and Fine Aggregate from natural sources of Concrete.
- IS:516-1959 Method for Test for Strength of Concrete.
- IS:1199-2018 Part 1 Sampling of Fresh Concrete.
- IS:1199-1959 Slump test for Fresh Concrete.
- IS:383 Aggregates for Concrete.
- IS:9103-1999 Specification for Concrete Mixtures.
- IS:10262-2019 Guidelines for Concrete Mix Proportioning.

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