

Utilization of waste paper-pulp by partial replacement of sand in concrete

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Abstract— Paper is a material produced by pressing together moist fibre of cellulose pulp derived from wood, rags and grass and drying into flexible sheets. Every year a huge amount of paper gets discarded of which only a minute fraction is being recycled and the rest gets dumped as landfills. It would be advantageous if this prodigious amount of waste can be utilized as a sustainable construction material and make it as a value added product. Paper-crete is an experimental material formed by using paper pulp in normal concrete. In this project, percentage of sand is replaced with paper-pulp to form paper-crete. The total weight and carbon dioxide emissions during its production as compared to the normal concrete are observed to be considerably reduced. Also, the optimum results regarding compressive strength and water absorption were achieved.

Index Terms— construction, ecofriendly, light weight, paper-crete, paper-pulp, sustainable, waste paper

1 INTRODUCTION

1.1 GENERAL

These days carbon dioxide emissions, global warming, forest destruction and lack of resources which made from construction sites because of use of cement is a global issue, on the other hand people's desire to live eco-environment is continuously increasing. Therefore, owing to increasing population especially in last decade which causes a chronic storage of building materials, the civil engineers have been challenged to convert the industrial waste to useful building and construction material. In order to resolve these kinds of matters this study is carried out. As well to meet the requirements of providing sustainable housing has led to greater interest in alternative construction materials.

A term has been coined for a relatively new material made of waste paper, aggregates, cement, and water. It is called "papercrete." It implies a mix of paper and concrete, hence paper-crete. But more accurately, only the Portland cement part of concrete is used in the mix – along with other admixtures. Although some people add sand and other additives to improve its behavior under compressive load, the basic components are still the same. The combination of these materials produces a new construction material, which may provide a way to produce affordable housing on a large scale.

According to the Environmental Protection Agency (EPA) (US EPA 2000), the United States of America recycles about 45 percent of discarded paper annually. This means that about 55 percent or 48 million tons of paper is thrown away or goes into the landfills. Conservatively speaking, it takes about fifteen trees to make a ton of paper. This means that 720 million trees are used once and then buried in a landfill each year. (point 6 from Reference)

The cement concrete remains the main construction material used in construction industries. For its suitability and its adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment, economize and lead to proper utilization of energy. Research on the usage of waste construction materials is very important since the material waste is gradually increasing with the increase of population and increase in urban de-

velopment.

1.2 Problem Statement

- The purpose of this research is to determine if papercrete has suitable properties to be used as construction material for homes.
- To find out if some subjective evidence about it is accurate and to determine areas of further studies.
- The parameters to be studied are compressive strength, water absorption test.

1.3 Objectives

- To analyze whether or not subjective evidence is accurate.
- To construct and verify the strength of the papercrete blocks.
- To find out the water absorption capacity of papercrete blocks.
- To analyze papercrete as a construction material to build low cost houses.

1.4 Scope of Study

- Determining accuracy of subjective evidence obtained from papercrete makers.
- Study the Compressive, Water absorption of papercrete and comparing it with conventional concrete blocks
- Comparison by weight.
- With compressive strength variation in percentage of proportion.
- Studying the sustainability of paper Crete

- Use of waste paper pulp in concrete can save the pulp and paper industry disposal costs and produce a greener concrete for construction
- Landfilling issues of paper of globalization can be reduced to some extent by partial replacement in concrete.

2 LITERATURE REVIEW

2.1 General

With reference to base paper mix design is considered.

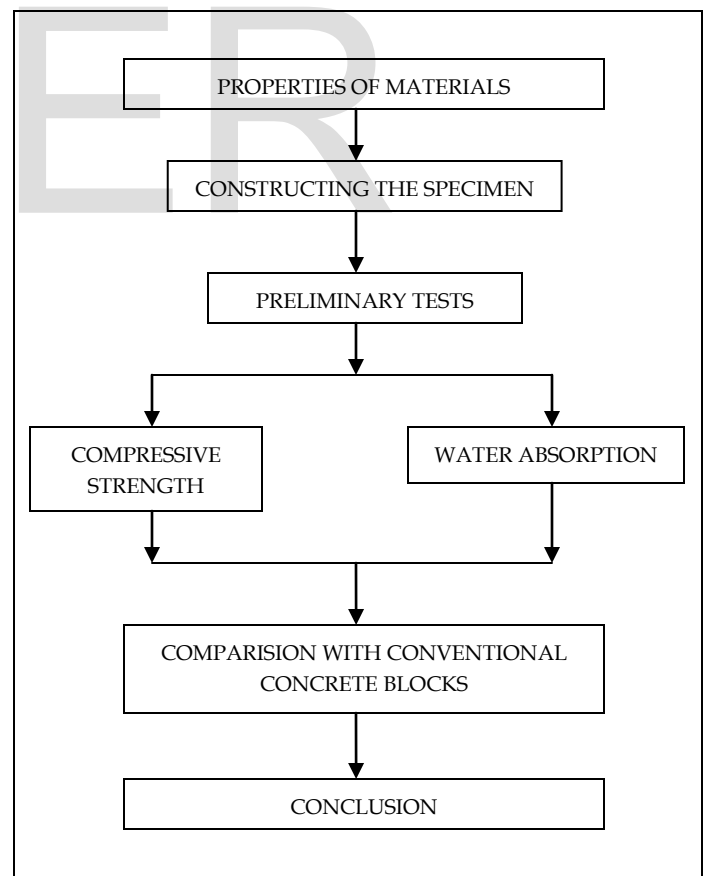
2.2 Review of Various Research Paper:

- A project conducted on “Experimental Investigation of using papercrete and recycled aggregate as a coarse aggregate” in 2015 - By T. Subramani, G. Shanmugam states that the aim of the project was to determine the strength and durability characteristics of high strength structural concrete by using recycled coarse aggregates with papercrete, which will give better understanding on properties of concrete with recycled aggregates and to determine the compressive strength of papercrete.
- In a study of “Structural properties of a new material made of waste paper” by Fuller B., Fafitis A. and Santamaria J, they have conducted some mechanical and physical parameters of papercrete to provide low cost, sustainable housing.
- Seyyedeh Fatemeh Seyyedalipour, Daryosh Yousefi Kebria, Nima Ranjbar Malidarreh and Ghasem Norouznejad state in their research work published in 2014 that the purpose of “Study of Utilization of pulp and paper Industry wastes in Production of Concrete” was to investigate the using of pulp and paper industry wastes in various concrete mixes containing various contents of the waste to reduce environmental effects of these wastes disposal.
- A Study of Papercrete towards building sustainable and resilient Infrastructure” by Syed Kaiser Bukhari, Maqbool Yousuf and Ayaz Mahmood Dar states that the investigations show that the papercrete can be used as a very good supplement of wood as it has strengths comparable to wood. The total weight, cost

and CO₂ emissions during its production as compared to the normal concrete are considerably reduced. The study also concluded that the dried papercrete has rough surface which increases its surface area and provides a very strong bond from one block to the next. There are significant challenges in constructing with papercrete but also opportunities.

- An “Experimental investigation of Papercrete Concrete” by T. Subramani and V. Angappan in 2015 aims to investigate the potential use of paper waste for producing a low cost and light weight composite brick as a building material depending upon the compressive strength and water absorption.

3 METHODOLOGY



3.1 PROPERTIES OF MATERIALS

3.1.1 Cement:

Cement is a fine powder used for bonding between components of concrete. In this project the cement would be **Ordinary Portland Cement (OPC) of 53grade J K Cement** cement. Cement should be stored in proper place to avoid formation of floc.

The cement used was subjected to various field tests like:

- The cement used had no floc.
- After throwing in water it floated on water form some time before sinking.
- After immersing our hand in cement, it gave us cool feeling.
- The Cement was easily passing through 90micron sieve.

3.1.2 Sand:

It is used as a filler material to fit the gap between the aggregates i.e. porosity of concrete is reduced. It also has high tensile strength that results from its fine-grained structure.

The main properties of Sand we used are:

- Specific gravity 2.5
- Water absorption 0.6%
- Fineness modulus 2.91

3.1.3 Aggregates:

- Grading: Grading refers to the determination of the particle-size distribution for aggregate. The aggregates should be such that larger area should be covered while casting the cube.
- Durability: Aggregates increase the durability of structures.
- Shape and Surface Texture: Particle shape and surface texture influence the properties of freshly mixed concrete more than the properties of hardened concrete.

Physical Properties of aggregates:

- Specific gravity 2.95
- Water absorption 1%

Average aggregates impact value 5.78

3.1.4 Paper:

Paper is a natural Polymer which consists of wood cellulose, which is the most abundant organic compound on the planet. Cellulose is made of units of monomer glucose (polysaccharide). Wood fragments are thermo metrically or mechanically treated to dissolve the lignin binder and to free the cellulose fibers. The Cellulose chains provide more stability and strength.

- Paper-pulp we used contained 85% of water.

- Lowest quality of paper was used, i.e. newspaper.
- Paper was soaked in water for 3 days for preparation of pulp and after that using putty mixer paper pulp was produced.

3.1.5 Water:

Water is an important ingredient of papercrete as it actively participates in the chemical reaction with cement. It should be free from organic matter and the pH value should be between 6 to 7.

3.2 MAKING OF SPECIMEN

SOAKED PAPER PULP



3.3 Preliminary Tests

3.3.1. Compressive Strength Test

Compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. On an atomic level, molecules or atoms are forced together in compression. Compressive strength is measured on materials, components and structures. Before the testing procedure is carried out, the irregularities in the surface are removed. Then the specimen is placed centrally on the bottom plate of Universal Testing Machine. By lowering the upper plate, uni-axial compressive load is applied at constant speed, uniformly distributed in order to develop stress vs. strain curve and determine the stiffness of the material. At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block will be noted. From the noted values, the compressive strength may be calculated by using below formula:

$$\text{Compressive Strength} = \text{Load} / \text{Area}$$

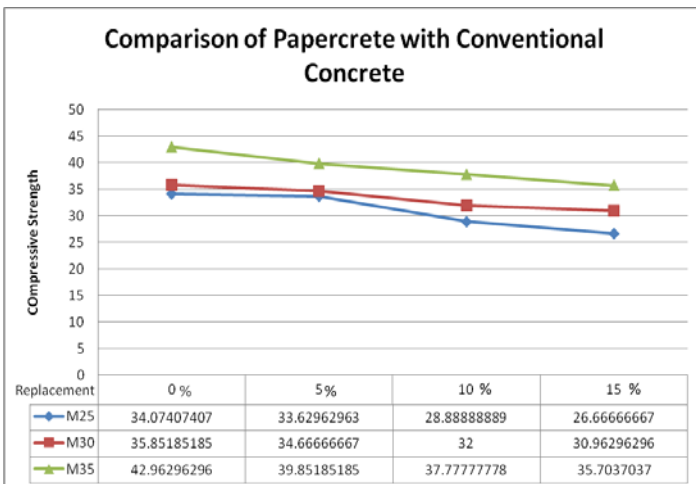
Size of the test specimen = 150mm X 150mm X 150mm

3.3.2. Water Absorption Test

The water absorption of Paper-Crete blocks is not related directly to the porosity owing to the nature of pores themselves. Some of the pores maybe those that permit air to escape in absorption tests and allow free passage of water in absorption tests, but other are completely sealed and inaccessible to water under ordinary conditions. For this, it is seldom possible to fill more than about three quarters of pores by simple immersion in cold water. More is the water absorption capacity weaker the papercrete block and vice versa. Dry the specimen in ventilated oven at a temperature of 105° C to 115° C till it attains substantially constant mass. Cool the specimen to room temperature and obtain its weight (M1). Specimen too warm to touch shall not be used for this purpose. Immerse completely dried specimen in clean water at temperature of 27° + 2° C for 24 hrs. Remove the specimen and wipe out any traces of water with damp cloth and weigh the specimen after it has been removed from water (M2). Water absorption value of papercrete block largely influences its bond with mortar. If water absorption in papercrete blocks is more and papercrete blocks are not soaked before the masonry work, the water from freshly laid mortar is likely to get absorbed by papercrete blocks. This results into poor mortar strength as the sufficient quantity of water will not be available for hydration process.

4 RESULTS

4.1 Compressive tests conducted



4.2 Water Absorption Results

Water Absorption			
Grade of concrete	Bulk density	Dry density	% Water absorption
M25- 5%	8.39	8.31	0.96%
M25- 10%	8.47	8.38	1.07%
M25- 15%	8.468	8.308	1.92%
M30- 5%	8.662	8.598	0.74%
M30- 10%	8.392	8.31	0.98%
M30- 15%	8.136	7.986	1.87%
M35- 5%	8.73	8.686	0.50%
M35- 10%	8.4	8.338	0.74%
M35- 15%	8.166	8.048	1.46%
M25	8.912	8.866	0.51%
M30	9.186	9.158	0.30%
M35	8.912	8.888	0.27%

5 CONCLUSION

- Increase in papermass in concrete, **increases water absorption** slightly compared to the water absorption capacity of conventional concrete blocks.
- **Compressive strength** is satisfied.
- Papercrete blocks are **light weight** and total dead load of the building will be reduced compared to conventional concrete blocks.

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- [9] IS: 456 – code of practice for plain and reinforced **concrete**; IS: 383 – specifications for fine & coarse aggregate from natural sources for **concrete**.

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