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An Environmental and Sustainable Alternative Building Material Papercrete Brick

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Abstract

Utilization of concrete in the construction industry is increasing day by day. The increasing demand for concrete in the future is the major issue, for which an alternate option is to find out at a reduced or no additional cost and to reduce the environmental impact due to increase of cement industries that are important ingredient to economic development. It turns out urgent to find out alternate for the partial replacement of concrete and cement, as natural sources of aggregates are becoming exhausted. As large quantity of paper waste is generated from different countries all over the world which causes serious environmental problems, So in this present study abandoned paper waste was used as a partial replacement material in concrete,. Study indicates that 80% of the construction cost of a building was contributed by building material and still millions of people in developing countries like India are not able to afford the cost of construction of house. This study is based on potential use of light weight composite brick as a building material and potential use of paper waste for producing at low-cost. Experimental investigation was carried out to analyse optimization of mix for papercrete bricks depending upon the water absorption, compressive strength and unit weight. Papercrete bricks were prepared out of waste paper, and quarry dust with partial replacement of cement by another industrial by-product Fly Ash in varying proportions of 25%, 40% and 55%. The properties like mechanical strength, standard quality comparisons with the conventional bricks through standard tests like hardness, soundness, fire resistance and Cost-Benefit Analysis were performed and studied. The specimens of dimension 230mm x 110mm x 80mm were subjected to 7 Days and 28 days air curing and sun drying before tests were performed on them. Based on the study it was found that for non-load bearing walls papercrete bricks are best suited.

Keywords: Low Cost Material, Waste Paper, Light Weight Material, Papercrete Hollow Block, Compressive Strength.

1. Introduction

Large amount of paper is used for different activities and four hundred and fifty (450) million tons of paper is produced across the world. It involves chopping off trees and deforestation that poses a major environmental problem faced by our society in the current scenario, as 42% of all global wood harvest is used to produce paper [1]. This causes contamination, which causes release of chlorine-based bleaches, which is used during production, and the methane gas generated as a result of rotting of paper [2]. The 3rd largest industrial polluter of environment is the pulp and paper industry and it is difficult to identify landfill sites to deposit them [1]. In Fast Growing countries, this causes a threat to municipal solid waste management. In 2015, approximately 62 million tons of municipal solid wastes were generated in India. Only 12 percent of this was processed and safely disposed. The staggering 88 percent of India's solid waste was dumped either in unsanitary landfills or in public areas indiscriminately [3]. It contains plastic waste, electronic and medical waste, construction and demolition waste etc. The raw materials required become deficit, when the waste produced reaches their maximum level.

A large demand being placed on the materials used for construction, this study aims in taking the best out of the paper waste, by utilizing it as a building material. The thrust on the construction material increases in proportion to the generation of waste paper. This inconsistency can be managed with the use of papercrete bricks. It not only leads to the natural resources conservations but will also harvest better ways of tackling residuals and by-products. The purpose of this research is to take advantage of the waste materials like paper and to replace the costly and rare conventional building materials. Papercrete material has been found many years ago but rediscovered recently [4]. Papercrete is a material consisting of fly ash, waste paper, quarry dust and

cement. To be used as a long-lasting building material, the substances are mixed with water, which can then be placed into a mould and allowed to dry.

2. Objective of the Research

The objective of the study is to investigate the properties of Papercrete bricks that were prepared out of waste paper, quarry dust and Fly Ash in varying proportions of 25%, 40% and 55%. The following properties were studied and a comparative study with conventional bricks was done:

- Mechanical properties
- Weight comparison
- Quality Standards like hardness, soundness and fire resistance
- Environmental compatibility

3. Experimental Procedure

3.1 Specific Gravity Test for Fine Aggregate and Paper Pulp

- A clean and dry pycnometer with its cap is taken and weighed in grams (W1). About 200g of dry sample (quarry dust or paper pulp) passing through it was put in it and gross weight of the pycnometer and the sand was again taken (W2).
- The pycnometerwas then filled with distilled water up to the hole in the conical cap and shaken gently until all the air bubbles escaped. Then the weight of the pycnometer with the sand and water was taken in grams (W3).
- The pycnometerwas then emptied and cleaned thoroughly. The clean pycnometerwas then filled with distilled water up to the hole in the conical cap and weighed in grams (W4).

3.2 Sieve Analysis

About 1 kg of dry sample of fine aggregate was taken and sieved on IS sieve number: 470, 240, 60, 30 and
15. This operation was continued until number particles passed through the sieves finally. Then the material retained in each sieve was collected and weighted. The results were tabulated and the percentage of fine aggregate of varying size that passes through each sieve was calculated and recorded. The value obtained was compared with grading limit chart for fine aggregate [7] and the actual zone, to which particular fine aggregate comes under, was determined.

3.3 Determination of Bulk Density

To find, the bulk density of quarry dust, the following procedure was employed. The empty weight of the container was taken as W_c. The container was filled with aggregates sample for about one third height and was tamped evenly with 25 blows. Similarly same quantity of aggregates were added as second layer and was tamped with 25 blows. A third layer of aggregate was added until it overflows and was tamped with 25 blows. Using tamping rod as a straight edge, the surplus aggregate was struck off. Measure the weight W_1. The container was emptied and it was filled again until it over flows using a shovel, aggregates being poured from a height not exceding 5 cm above the top of the container. Surface was leveled and the weight was taken as W_2.

3.4 Specific Gravity of Fly-Ash and Cement

The procedure to find the Specific Gravity of Fly-Ash/Cement is as follows . Having taken a clean and dry Le Chatlier Flask with its stopper, its weight was measured as W1. Filling half the flask with test specimen (fly ash/cement) the weight was measured as W2. Following which kerosene was added until it is partially filled. The mixture was mixed using a glass rod to remove entrapped air. Stirring was continued and more kerosene was added up to the graduation mark. The weight W3 was measured. Emptying the flask and refilling it with clean kerosene up to the graduation mark the weight W4 was measured.

Specific gravity of fly-ash/cement was then calculated by using the formula given in Eq. (1): Specific gravity = W3 – W1/ [(W4- W2) – (W3-W1) X 0.79]

3.5 Quality Standard Tests on Papercrete bricks

This involves the study of various qualities of Papercrete bricks. The presence of soluble salts was determined by efflorescence test. In which the fibrous concrete brick was immersed in water for 24 hours. Following which they are kept in shade to dry. Having taken all the three proportion bricks, the hardness of the brick was determined by making a scratch on the brick surface. To study the soundness property of the brick, two bricks of same proportion were struck with each other. By setting a few bricks to fire, it

enabled the study on the fire resistive nature of the bricks. In projects we prefer a simple and easy test that can be conducted in a very short span of time for certain specifications and to control the quality. The very thought is that we can make use of rapid chloride permeability test (RCPT). By observing the quantity of flow of electrical current through a 50 mm thick by 100 mm in diameter sample for duration of 6 hours, the rapid chloride permeability test was performed. The sample was cut as a slice of a core or cylinder. Throughout the test a potential difference of 60V DC was sustained across the electrodes. One lead was immersed in a 0.3 M caustic soda (NaOH) solution and the other in a 3.0% salt (NaCl) solution. A conditional ranking was made for the concrete's permeability based on the charge that passes through the sample. Finally, in compression testing machine the brick was tested for cracking pattern under different loads.

4. Results and Discussions

As per the procedure given, to study the properties of the brick various tests were conducted. On performing the Specific Gravity Test on Fine Aggregates for three different samples, the specific gravity was calculated as 2.52. The summary of the entire result is shown in Figure 1. Secondly, Sieve Analysis test performed on quarry dust revealed that it has a fineness modulus of 2.8 and the data obtained is tabulated in Table 01. From the results obtained in the table, a graph was plotted between sieve sizes and the percentage passing as shown in Figure 2. The third test being the determination of bulk density of quarry dust, helped in calculating the value of bulk density of compacted quarry dust as 1.7kg/l and that of loaded quarry dust was 43%. By Le Chatelier method, the specific gravity of Fly-Ash and Cement was determined. Specific gravity of cement was 3.13 and fly ash was 2.33. Specific Gravity Tests on Paper Pulp was done and the results are shown in Figure 3.

Among the Quality Standard Tests, Efflorescence Test on Papercrete Bricks proved no white or grey surface deposits on the bricks. Hence, the bricks are free from soluble salts (Figure 4). The result of Hardness Test proved that the brick is sufficiently hard with a less impression due to the scratch. The clear ringing sound produced during the Soundness Test proves that the bricks are good. From Fire Resistance test, it was observed that in an open flame the Papercrete bricks did not burn. They burnt slowly like charcoal. However flaming for several hours, these bricks would be reduced to ashes as shown in Figures 5 and 6. If the interior plaster and exterior stucco are provided in papercrete bricks, the bricks will not burn. In addition, if plaster is applied without any holes or leakage in the bricks, due to absence of oxygen it will not get burnt inside. As we know corrosion of the reinforced steel which is held within the concrete as a result of chloride intrusion is a frequent environmental attacks that guides to the downturn of the concrete structures.

This durability issue has received prevalent awareness in modern years due to its reg lar occasion and the linked high cost of repairs. Rapid Chloride Permeability Test (RCPT) results indicated Chloride permeability as per ASTM C1202 as HIGH. Conventional Bricks are highly brittle in nature and fail as soon as load is applied. They usually crack from middle and break into multiple pieces. However, papercrete bricks never failed catastrophically, they just are compressed like squeezing rubber. Therefore, the test was conducted under full compression. Even at higher load, the structure experiences outer face cracks and peels out without structural fail, whereas the papercrete brick failed. This is mainly due to the higher elastic nature at failure which compresses like rubber. Since the bricks experiences compression under heavy loading, the roof may get collapsed resulting its application for non-load bearing partition walls alone.

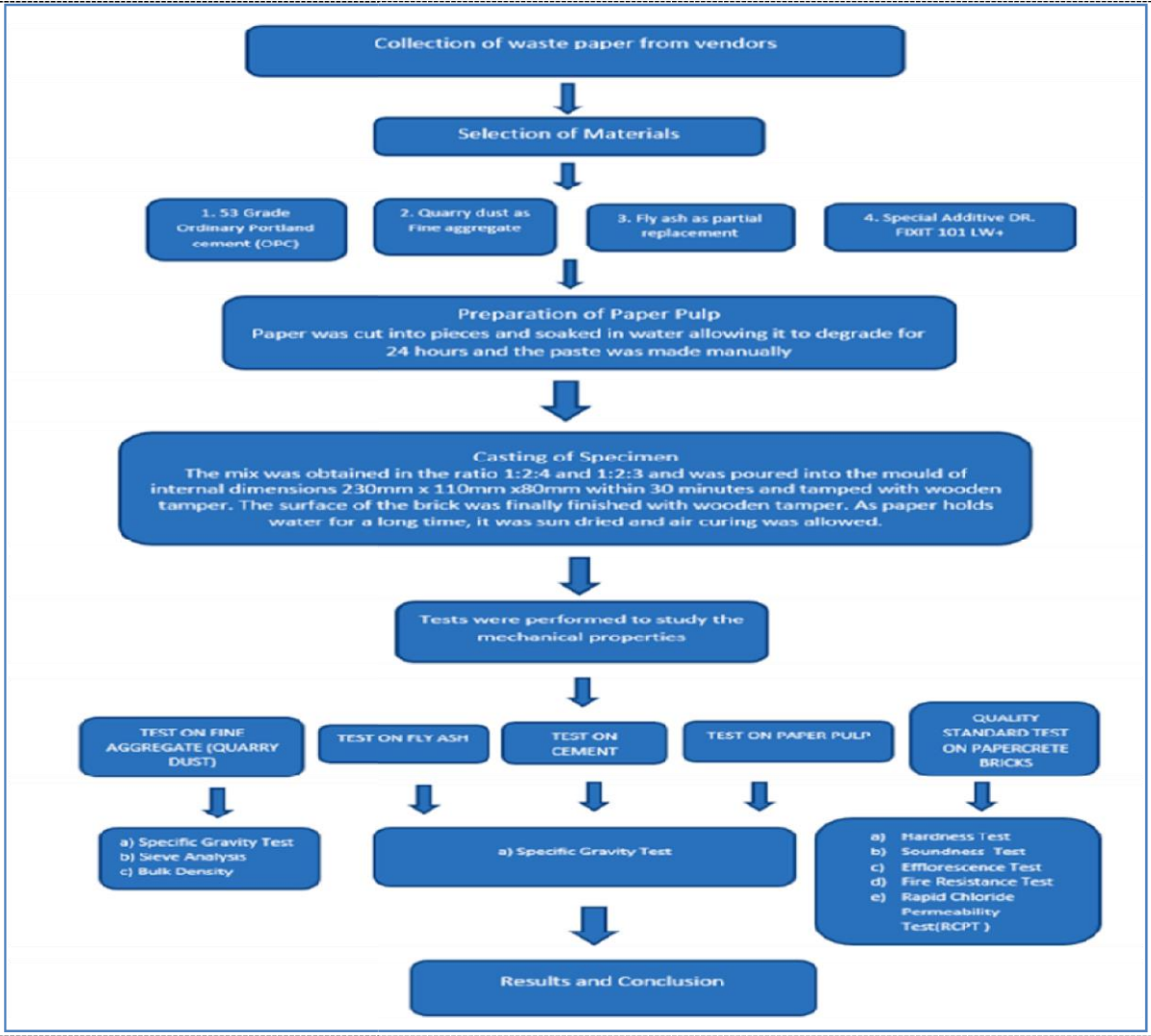

Figure 1. Flow Chart Showing Experimental Procedure.

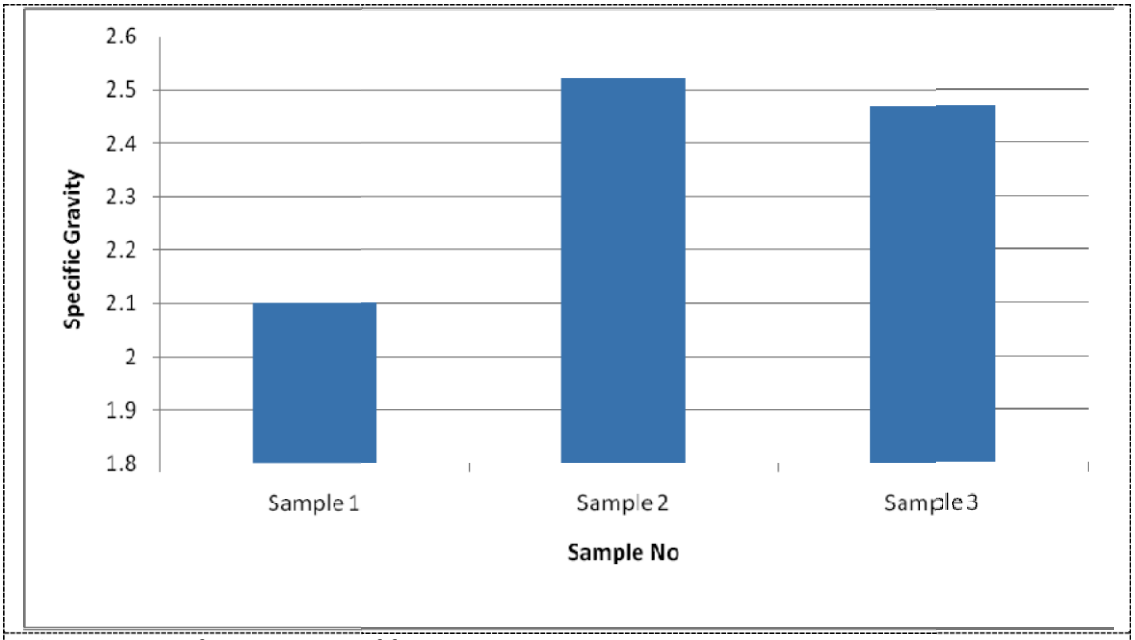

Figure 2. Specific gravity test of fine aggregates.

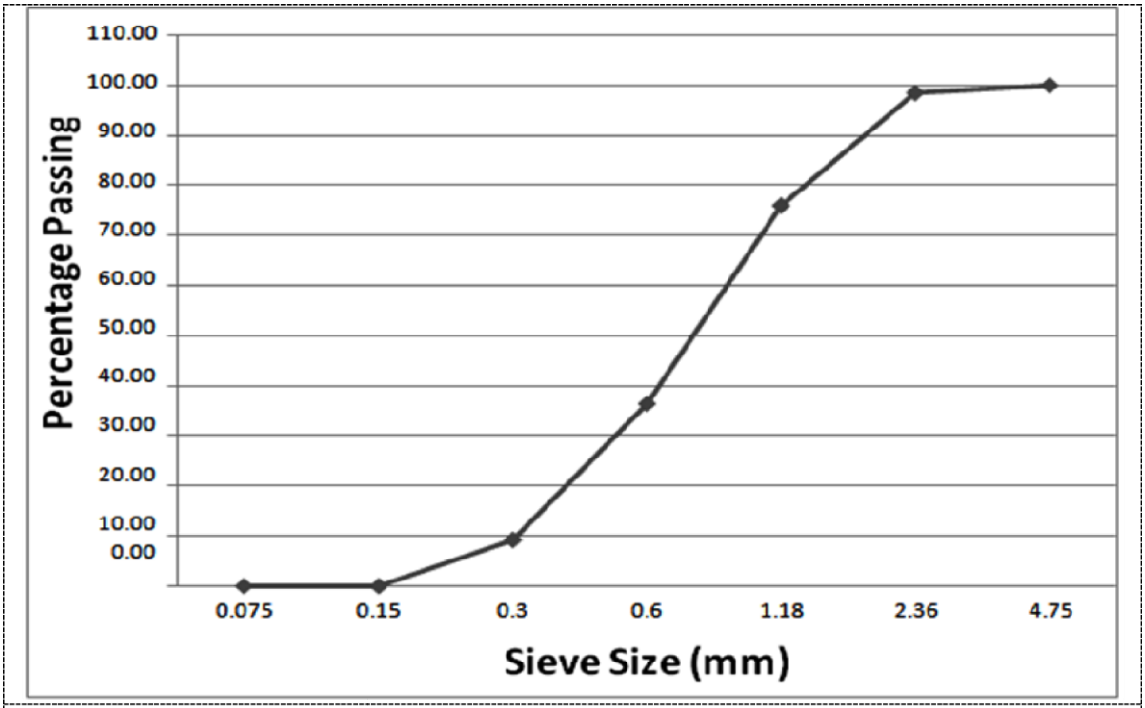

Figure 3. Sieve Analysis of Fine Aggregate.

Table 1 Sieve Analysis of Fine Aggregate

Sieve Size	Weight Retained	% Weight Retained	Cumulative % Weight Retained	% Passing
4.75mm	0	0	0	100.00
2.36mm	15	1.5	1.5	98.50
1.18mm	225	22.5	24	76.00
600 µ	396	39.6	63.6	36.40
150 µ	92	9.2	100	0
75 µ	0	0	-	-
Pan	-	-	-	-
			$\sum = 279.9$	

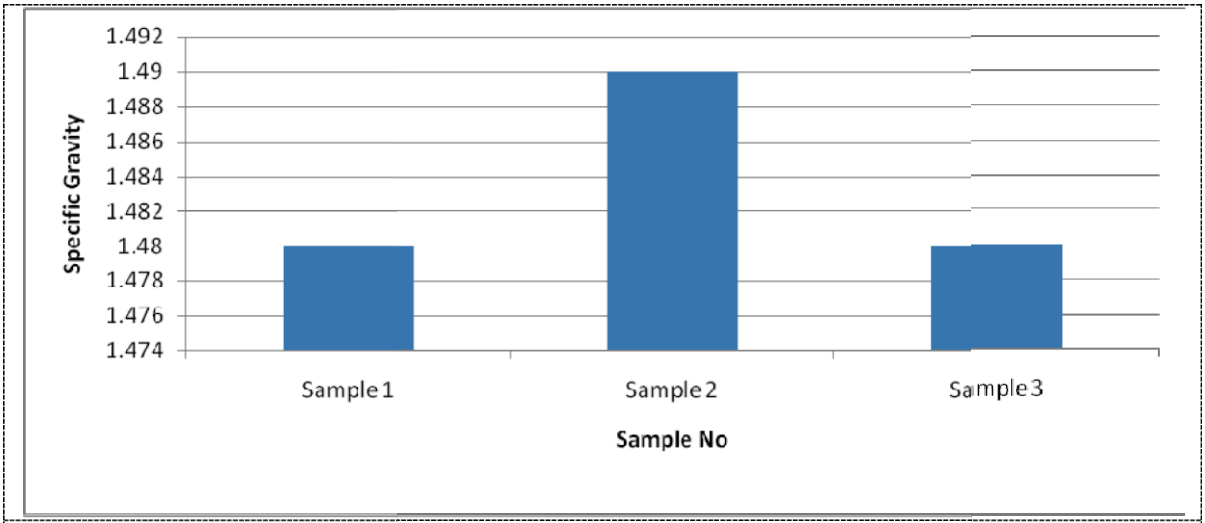

Figure 4. Specific gravity test of paper pulp.

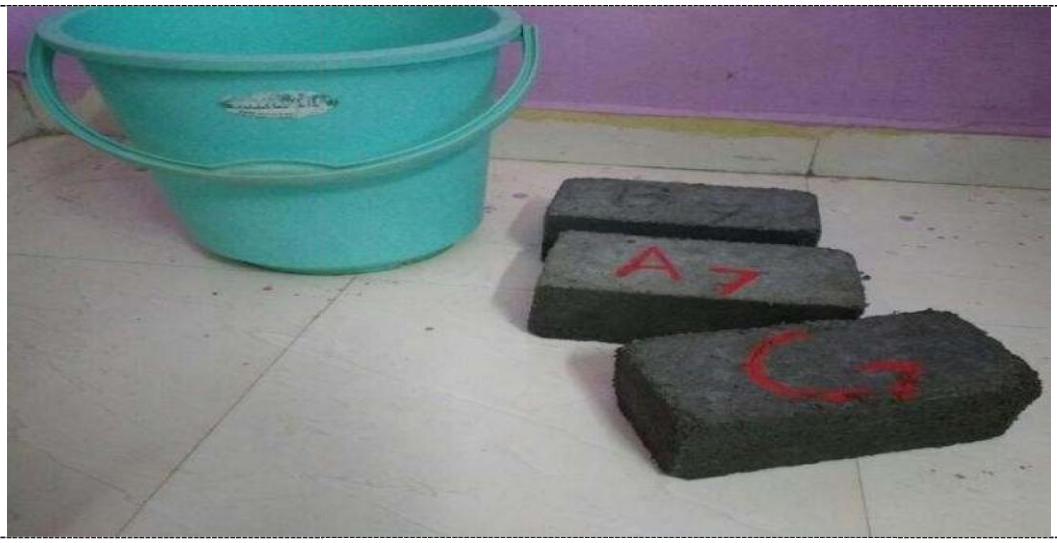

Figure 5. Efflorescence Test of Papercrete bricks.

Figure 6. Papercrete brick during fire test.

Figure 7. Papercrete brick after fire test.

4. Conclusion

Papercrete bricks satisfy the basic characteristics of conventional bricks as various tests results proved in the study. The basic qualities of conventional brick are: they should be of uniform colour, should have even surfaces, free from cracks and should have sharp and defined edges. They should be hard; so that no impression is left when scratched with fingernails and should produce clear ringing sound when struck with each other. The bricks when tested in accordance with the procedure laid down, the rating of efflorescence shall be 'Nil'. Average weight sho ld be 30N to 35N.And the specific gravity ranges from 2.6 to 2.8. The bricks should have low thermal conductivity and should have percentage of water absorption by weight less than 20%, when soaked in cold water for 24 hours. The above characteristics are clearly observed in our study and they are special in the case of fire resistive nature. Thus, papecrete bricks prove to be one of the emerging solutions for eco-friendly buildings.

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