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**International Journal of Research Publication and Reviews**

Journal homepage: www.ijrpr.com ISSN 2582-7421

# Effect of Partial Replacement of Cement by Paper Pulp in Concrete - A Literature Review

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**ABSTRACT-**

The major problem faced in Construction industry is the environmental pollution. Similarly, Papers were used and reused several times and ends in a form of solid waste. Cement, sand, coarse aggregate and water are the materials to make concrete. Papercrete is a one type of fibrous cement, made by shredding paper such as old newspapers, prints, cardboards etc. as pulp in water.. The waste paper has been dumped as waste and causes environmental pollution behind mill or landfill. It has numerous advantages in construction industry, recycled material usage, high strength to weight ratio, high thermal insulation, high sound absorption, aesthetic and cost effective. The industry paper wastage for every year is increasing gradually. More spaces are being needed for landfills, uses energy loss of natural resources and increase of expenditure and various types of pollutions. Utilizing waste paper as cement replacement or addition in concrete production will reduce environmental pollutions. This review paper is to investigate the effect of waste paper on mechanical properties of concrete such as compressive strength, split tensile strength, flexural strength, water absorption and durability. From many previous studies before this, 5% and 10% waste paper as cement replacement and additions were the ideal percentages to increase the compressive and flexural strengths of concrete. This study indicates waste paper can give benefit by using it as additional material in concrete production.

***Keywords- Paper Pulp, Papercrete, PPC, Water Absorption, Compressive, Splitting Tensile and Flexural Strength, Durability etc.***

## 1. INTRODUCTION-

A large amount of non-renewable resources is consumed by the construction industry throughout the world. Everyday tons of waste papers are discarded as landfill or dump sites than those recycled. It is learnt that it takes about fifteen trees to make a ton of paper which means that 720 million trees are used once and then buried as landfills each year. In order to address these issues it has become imperative to push the boundaries of research in the field of innovative sustainable construction materials. By using waste paper, the cement amount used reduces as it provides an environmentally friendly construction material. Portland cement and waste paper are the materials that make a fibrous cemented material called papercrete. Papercrete is also known as fidobe, fibrecrete, padobe etc. Papercrete is an innovative composite material developed to build an environmental friendly house made up of paper, cement and water. It has been reported to be a cheap alternatively building construction material, to have a good absorption and thermal insulation, to be a light weight and fire resistant material. When paper is mixed with cement, it creates a very good bond and the final product is both lightweight and strong. Fibres contribute to sound insulation properties and help in crack control. Cement reduces the drying time and the effect of pulp shrinkage and increases the strength and dimensional stability. The environment impact of paper is significant, which has led to changes in industry. The production and use of paper has a number of adverse effects on the environment which are known as paper pollution. Discarded paper is a major component of it. Taking this issue into account, construction material known as papercrete is invented. Moreover, waste paper can be used in the right way by using it in construction materials to reduce its density. Furthermore, due to its lightweight characteristic, papercrete can also be used for the interior wall of a high-rise building in seismically active regions. Moreover, papercrete usage will decrease the dead load of the structure, the depth of foundation required and the percentage of steel used, so the labour amount and energy expense will be decreasing significantly. The effect of waste paper on mechanical properties of concrete such as compressive strength and flexural strength are reviewed in this paper based on numerous research papers before this.

## 2. REVIEWS OF ARTICLES

**[1] Bai, J. et al. (2003). Compressive Strength and Hydration of Wastepaper Sludge Ash–Ground Granulated Blast furnace Slag Blended Pastes. Cement and Concrete Research, Volume 33, Issue 8, August 2003, Pages 1189-1202**

The following conclusions may be drawn from this study:

1.Waste paper sludge (which comprises an intimate mixture of finely divided calcium carbonate and kaolin) when heated rapidly (3–5 s) up to a maximum temperature of 1200 °C and then cooled rapidly (3–5 s) to 200 °C, forms a fine ash (WSA), which has cementitious properties.

2.The ash consists of several different crystalline phases, the principal ones being gehlenite, quicklime and α′-$C_2S$/bredigite, together with small amounts of hydrated lime

**[2] Titzman L.C.(2006) "Analysis of Low Cost Building Material for the Mix Alco Process" Texas A & M University, 2006.**

The compressive strength increases up to 10% addition of SWP. However, above 10%, the strength reduces gradually. The flexural strength increases up to 10% addition of SWP, and more than 10% SWP content decreases the strength gradually. Adding SWP to concrete mix prompts increment in water absorption. The higher SWP addition causes higher concrete water absorption. Generally, 5% to 10% addition of SWP is the most suitable mix proportion. SCBWP has higher compressive and flexural strengths and water absorption than SCPWP because SCBWP has higher cellulose, more fibre average length, a higher proportion of medium and long fibre contents than SCPWP. By using SWP in concrete, the disposal cost of a paper industry can be saved, and sustainable concrete can also be produced in the construction and civil engineering fields. The utilization of waste material such as SWP as an additional alternative material in concrete will give advantage to the environment. The advantage of using this waste material also gives benefit to the economy in term of cost-effectiveness.

**[3] Yun H., Jung H., Choi C.(2007)"Mechanical Properties of Papercrete Containing Waste Paper", Architectural Institute of Korea, 2007.**

From this investigation, the following conclusions can be followed:

(1) The density of papercrete was decreased when the replacement ratio of waste paper of papercrete increased. When paper replacement ratio was 5%, density was measured 1.88g/cm³, and it was reduced to 15% and 22%, respectively by increasing paper ratio 10% and 15%.

(2) The average compressive strength of group PA which include 5% paper-cement replacement ratio was 34MPa and water-binder ratio hardly affected compressive strength of papercrete. The compressive strength of group PB(paper replacement ratio 10%) and PC(paper replacement ratio 15%) was increased slightly by decreasing sand-binder ratio to 0.75 and 0.50.

(3) The splitting tensile strength of group PA was 3.60MPa, PB was 2.9MPa and PC was 2.53MPa. The splitting tensile strength also decreased by including higher replacement ratio of waste paper.

**[4] Dunster Andrew et al. (2007)** concluded from their research work that the addition of 20% calcined paper sludge with cement paste modified initial setting-time by accelerating the process in 60 minutes. The incorporation of 10% and 20% thermally activated paper sludge leads to an increase in the drying shrinkage of mortar 2 and 2.5 times more than that shown by the ordinary Portland cement used as control

**[5] Gunarto A, Satyarno I, Tjokrodimuljo K.(2008) Newsprint Paper Waste Exploiting for Papercrete Panel. Institute of Research Center, Gadjah Mada University. 2008**

1. Papercrete is far lighter a material than concrete or wood and has good water absorption and insulation capacity, less shrinkage and is environment friendly, has high strength to weight ratio.

2. Although this area requires significant amount of research, but papercrete can ideally be used for reduction in dead weight of structural elements in cases where there are no special loads acting on the element. Also, about 55% of paper waste around the globe still does not get recycled and is directly disposed of and a considerable portion of it can be used for manufacturing papercrete. Future research on improving its tensile strength can open up the possibilities of papercrete using it as a construction worldwide.

**[6] Malthy and Jegatheeswaran(2011)** conducted an experimental study which investigated the potential use of paper waste for producing a low-cost and light-weight composite brick as a building material. They investigated three different mix proportions of fly-ash-mixed papercrete blocks with and without sand. In all three bricks, the compressive strength was more than the required, i.e., 3.5 MPa. The bricks have water absorption more than 20%. Papercrete blocks did not burn with an open flame. They smoldered like charcoal but if the interior plaster and exterior stucco is provided on the bricks, the bricks would not burn at all. The results showed that the effect of high-level replacement of paper wastes does not exhibit a sudden brittle fracture, and it reduces the unit weight dramatically and introduces a smoother surface compared to the current conventional bricks and concrete blocks in the market. They concluded that papercrete bricks can be used for walls and as wooden board substitute and as best alternative for conventional bricks.

**[7] M.S. SUGANY (2012) Investigated on Papercrete bricks** has reported as Papercrete bricks are relatively light weight, and more flexible, these bricks are potentially an ideal material for earthquake prone areas. Papercrete bricks are good sound absorb.

[**8] "Structural properties of a new material made• of waste paper" by Fuller B., Fafitis A. and Santamaria J(2013)**, they have conducted some mechanical and physical parameters of papercrete to provide low cost, sustainable housing

**[9] Issac I. Akinwumi et al. (2014)** worked over two categories of Papercrete former was prepared by waste newspaper whereas waste office paper were used in the later. The specimen thus formed has the respective ratios of cement: sand: waste paper as 1:1:0.2, 1:1:0.4, 1:1:0.6 and 1:1:0 and were tested for density, compressive strength, water absorption and fire resistance. The conclusion drawn revealed that the specimen with waste paper had improved test result than the specimen without waste paper.

**[10] M. Rame Gowdal, K. Prasanna (2014)** Studied the Some **Properties of Papercrete Concrete** and they carried various experimentations on the cubes made with different proportions of cement, sand, paper and fly ash for determination of some engineering and physical properties. They concluded from the results of these experiments that the conventional blocks prepared without paper were bulky and not properly moulded and finished to desired shape whereas the blocks with modified mix had light weight, could be easily moulded to any shape and the finished surface was also very good.

**[11] "Experimental Investigation of using papercrete and recycled aggregate as a coarse aggregate"(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.

**[12] "Experimental investigation of Papercrete Concrete" by• T. Subramani and V. Angappan(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.

**[13] K. Anandaraju et al. (2015)** studied and they defined the term „Papercrete" as a mix of concrete and waste paper. Their exists different types of Papercrete with varying percentage of waste paper. They had not given any thumb rule to inculcate the percentage of waste paper. They used trial mix proportions and determine a standard proportion of Papercrete which provides required physical properties. In their study, they carried out test for many physical properties to determine the best mix, some of these are density, mechanical properties, flame retarded and thermal properties.

**[14] Shivangni Khandelwal et al. (2015) studied the trend of density with varying Papercrete proportions**. The conclusion reported that with increase in percentage of waste paper, the density of resulting mix will decrease. In their research, they tested Papercrete for compressive strength and shear strength. The compressive strength ranged between 140-160 lb/square inch and the R-value of Papercrete was in between 2-3 per inch in the test of Papercrete block for shear strength. They also stressed over the inflammability of Papercrete as it was not burnt in an open flame.

**[15] Jawahar Singh, Premit Kumar Patil (2016)** In this paper, reported that concrete were produced by mixing adequate amount of the waste paper sludge and water, and they compares slump value. In this paper concluded that compressive, splitting tensile and flexural strength increased up to 10% addition of waste paper sludge and future increase in waste paper sludge reduces the strength gradually. The cement had been replaced by waste paper sludge accordingly in the range of 5% to 20% by weight

**[16] Iqbal N. Gorgis, Harith M. Zaki and Shakir A. Salih (Dec 2017) "Properties of Papercrete"** Based on the test results in this work, the following conclusions can be drawn: Adding waste paper to concrete mix led to increase in water absorption and decrease in dry density for all mixes used except the mixture with 5% of paper pulp. The results of dry density indicate that lightweight concrete could, be produced by adding waste, paper. Compressive strength, splitting, tensile strength and flexural strength for mixes decrease with increasing of amount of wastepaper. While the mixture with, (5%) indicate strength nearly equal to that of reference mix.

**[17] Mechanical properties of papercrete Harith Zaki1,*, Iqbal Gorgis1 and Shakir Salih 1 MATEC Web of Conferences 162, (2018)**

The low bulk density of papercrete demonstrates that waste paper could be an important alternate sustainable material for production of light weight concrete. The reuse of wastes is essential from various perspectives: It helps to save and sustain the natural resources which are not replenished; it decreases the pollution of the environment and it also helps to save and recycle energy in the production process. Additionally, suitable landfill sites are becoming more difficult to find as urban areas expand. It has been confirmed that adding waste paper has a distinct antagonistic impact on the slump and fresh density. For which request higher water or higher chemical admixture dosages to keep the slump values as far as possible.

**[18] Seyyedeh Fatemeh Seyyedalipour, Daryosh Yousefi Kebria, Nima Ranjbar Malidarreh and Ghasem Norouznejad(2018)** 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.

**[19] A Study of Papercrete towards building sustainable and resilient Infrastructure" by Syed Kaiser Bukhari, Maqbool Yousuf and Ayaz Mahmood Dar (2018)** 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.

**[20] A Study on Partial Replacement of Cement By Waste Paper Pulp In Concrete Jagdish D. kalapad1 , Mohan Mansute2 , Vishal Swami3 , Vaishnavi Sulbhewar4 , T. M. Khandale5 International Journal of Innovations in Engineering and Science, Vol. 4, No.4, (2019)**

From this study it can be inferred that waste paper sludge is a good substitute for cement in the production of concrete. In this study, considering the strength as the criteria, 5% to 10% replacement gave optimum results. 8.1. Here was an increase in compressive strength of about 7.5% at 28 days for 5% replacement of cement compared to reference mix of M25 concrete. 8.2. From the cost comparison of paper sludge concrete with conventional concrete, it was found that the former is economical for bulk works. 8.3. One of the major challenges of our present society is the protection of our environment. The use of paper sludge in concrete can save paper industry disposal costs, landfill problems and produce a greener concrete for construction. 8.4. With the addition of waste paper sludge, there was a slight reduction in the workability.

**[21] Gundu M., Abhaysinha S. (2020). Experimental study on the performance of concrete mix with paper waste, waste plastic, quarry dust, and fly ash. Journal of Engineering Sciences, Vol. 8(1), pp. H1–H7, doi: 10.21272/jes.2020**

From the tests and results on plastic waste, paper waste, fly ash, and quarry dust in concrete, the following conclusion is drawn. The compressive strength of concrete started to decrease with the addition of plastic waste. This may be due to the flaky and elongated shape of plastic. The weight of the concrete decreases with the addition of paper and plastic waste. The cost of concrete reduces with the use of the wastes. The split tensile strength initially decreases,

and with the addition of plastic, the strength increases. Based on the study results, fly ash of 5 %, paper pulp of 3 %, and plastic waste of 5 % can be used in producing concrete. These wastes can be used to reduce natural resources. Since the presence of paper waste in concrete, we cannot use this concrete in the water logging area. It can be used by providing a waterproofing coating.

**[22] Experimental Study on Fractional Replacement of Cement with Waste Paper Pulp in Concrete Shoib Bashir Wani, M S Haji Sheik Mohamme International Journal of Innovative Technology and Interdisciplinary Sciences (2021)**

The percentage substitution of cement in M25 grade concrete was done by 5%, 10%, 15%. The different strength tests were carried and compared with conventional concrete samples. The following deductions were drawn:

- The slump value was gradually decreasing when the cement was partially replaced with waste paper pulp. The 5% replacement of cement in M25 grade Concrete yielded 4% less slump value than conventional concrete. However, 10% and 15% replacement of cement resulted in less workable concrete mixes.
- The compressive strength was increased by 15.5% by 10% replacement of cement. The strength was almost the same for 5% substitution and there was a fall in compressive strength of about 16.67% for 15% replacement of cement with waste paper pulp than conventional concrete samples.
- The tensile strength was increased by about 7.5% by 5% substitution and increased by 3.6% by 10% substitution of cement with waste paper pulp and it decreased gradually after 10% substitution than conventional concrete samples.
- The flexural strength was increased by about 10.89% for 5% replacement. There was a raise in flexural strength of about 2.5% for 10% replacement and a decrease in flexural strength of about 13.9% for 15% replacement of cement with waste paper pulp than conventional concrete samples.

**[23] Deepti Thakur, Mr. Shrikant Mishra Volume 7, Issue 11, November – 2022 International Journal of Innovative Science and Research Technology ISSN No:-2456-2165** "**An Experimental Investigation of Structural Properties of Paper Pulp Based Concrete"**

It has come to the following conclusion.

1. The amount of slump up to 5% instead of the amount of slump increased by 5%.
2. The composting of the waste paper concrete, has10% and 15% paper waste, showed a 6% decrease. In addition when the volume of paper waste did not increase by 20%, the price of paper dropped by 12%.
3. The compressive strength, which separates the tensile strength and the tensile strength until it is increased by 10% cement with a drop sheet after which it gradually decreases.
4. Competitive power decreased by 2.1% after replacing 20% cement with paper pulling.
5. Replacement of cement with 5 to 10% waste paper shows ideal results.

In this paper concluded that compressive, splitting tensile and flexural strength increased up to 10% addition of waste paper sludge and future increase in waste paper sludge reduces the strength gradually. The cement had been replaced by waste paper sludge accordingly in the range of 5% to 20% by weight

## 3. CONCLUSION

From the extensive literature review done on the topic, the following conclusions can be drawn about the effect of waste paper on concrete.

1. Papercrete can ideally be used for reduction in dead weight of structural elements in cases where there are no special loads acting on the element and it has cementitious properties
2. Depending upon 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. The compressive strength increases up to 10% addition of SWP. However, above 10%, the strength reduces gradually. The flexural strength increases up to 10% addition of SWP, and more than 10% SWP content decreases the strength gradually. Adding SWP to concrete mix prompts increment in water absorption.
4. The density of papercrete was decreased when the replacement ratio of waste paper of papercrete increased. When paper replacement ratio was 5%, density reduced to 10%, and it was reduced to 15% and 22%, respectively by increasing paper ratio 10% and 15%.
5. Adding waste paper to concrete mix led to increase in water absorption and decrease in dry density for all mixes used except the mixture with 5% of paper pulp. The results of dry density indicate that lightweight concrete could, be produced by adding waste, paper.
6. The slump value was gradually decreasing when the cement was partially replaced with waste paper pulp
7. The compressive strength was increased by 15.5% by 10% replacement of cement

8. The tensile strength was increased by about 7.5% by 5% substitution and increased by 3.6% by 10% substitution of cement with waste paper pulp
9. The flexural strength was increased by about 10.89% for 5% replacement. There was a raise in flexural strength of about 2.5% for 10% replacement

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[9] Issac I. Akinwumi et al. (2014)

[10] M. Rame Gowdal, K. Prasanna (2014)

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