Recycling wastepaper papercrete to produce green concrete

Aseel B Al Zubaidi*, Shatha R Ahmedizat1, Ahmed A Al-Tabbakh2

1Materials Engineering Department, University of Technology, Baghdad, Iraq
2Departments of Physics, Al- Nahrain University, Jadiriya 64055, Baghdad, Iraq

*Corresponding author: dr.material@yahoo.com

Abstract. This research studies using wastepaper as a replacement material in concrete blends. A concrete mollified wastepaper created via adding wastepaper as partial replacement through cement’s weight. Furthermore, it might be considered as eco-friendly, construction material was reduced amount of wastepaper. Inherent strength was gained because of the presence regarding the hydrogen chains in wastepaper’s microstructure. Papercrete has less costs in comparison to substitute building construction materials, energy absorption. Sound absorption and low thermal insulation were enhanced by papercrete. The different presents of wastepaper used after treating namely 0%, 5%, 7% in addition to 10% through partial replacement that is related to the cement’s weight for studying concrete blend’s mechanized properties like flexural tensile strength, splitting strength, compressive strength and put to comparison with the conventional mix. The results have specified that the flexural tensile strength, splitting strength as well as compressive strength decreased as the wastepaper’s content increased.

Keywords: Wastepaper; Compressive strength; Splitting tensile strength; Flexural tensile strength; recycling waste materials

1. Introduction

The concrete is made with materials waste which are eco-friendly so called as Green concrete. Papercrete is considered as one of the complex materials which consists of wastepaper, Portland cement, sand and/or water. Papercrete has good properties such inexpensive substitute construction material, have good thermal insulation and has light weighted. Papercrete was made by mixing sufficient a content of wastepaper with Portland cement kind I, water, sand and gravel, and then strength properties were compared with to normal concrete. These results specified that certain mechanical strengths including flexural tensile strength split strength in addition to the compressive strength increased to 5% adding of paper paste, also the increase in wastepaper pulp result in a decrease in the strengths. Paper consist of, majorly the wood cellulose, that is referred to as fibrous material. Wastepaper was used as construction materials for many years, chiefly in the cementitious matrices, a lot of studies were conducted for improving the mechanical properties related to the concrete modified regarding pulp wastepaper. Utilization regarding the paper industry wastes (hypo sludge) in the concrete mixes with various percentages producing minimum costs concrete through mixing various percentage ratio related to the cement with paper industry to minimize dispose and waste pollution. They tested using paper industry waste in the concrete formulation as supplemental cementations material as substitute to the normal concrete. Cement has been substituted through wastepaper sludge in range 0%, 10%, 20%, 30% as well as 40% through weight of M-25 and M-40 Mix from result found that using hypo sludge in the concrete might be saved certain paper industry disposal cost as well as creating greener concrete with regard to buildings. As well as the compressive strength was raised slightly to 10% with adding hypo sludge and more elevation in the hypo sludge will gradually reduce the strength (“Pitrode et al, 2013”)
[1]. Study of ground concrete with loose paper sludge. It has an apparent density of (460kg/m³), also specific density (2.6), in addition to ash content (94%). The material is essentially composed of amorphous and aluminato silicates, mainly gehlenite (2 CaO.Al₂O₃SiO₂) and Melilite (8CaO3Al₂O₃MgO5SiO₂); who is responsible for a pozz, the fluff reaction. Because of these elements, the paper sludge acts like a cementitious material and can be used as a binder in concrete (R.Srinivasan et al, 2010) [2]. have studied the effect of using waste paper as additional in concrete mixes. Wastepaper was taken from universities, administration offices, planning and libraries. The concrete mixes were prepared with various percent paper contents and specified the major strength characteristics like compressive strength. Flexural strength, split strength, density, as compared with to conventional mix. Five concrete mixes containing waste paper of 0%, 5%, 10% and 20% by weight of cement as an addition of wastepaper to the concrete have been prepared through ratios of (1:1.9:2.5) by cement’s weight, sand, aggregate. The results indicated that the fresh properties have been impacted considerably after increasing wastepaper content. Furthermore, density, flexural strength, compressive strength, in addition to the split strength have been decreased with the increase in percent ratio regarding wastepaper addition [3]. Cellulose fiber; insulation will be using recycled newspaper as raw material, from which the raw fibers will be subjected to extraction and treatment with certain additives regarding fire proofing, in addition to preservations against pests. The technology of manufacturing involves application through injection regarding the cellulose fibers. Furthermore, it might be utilized with regard to thermal insulation; of roofs, floors, walls, in addition to ceilings, it also has excellent sound insulation [4]. Papercrete must not be applied for the external walls as well as near-ground walls because of its high capacity for water absorption. In the case when using it for the external walls, wall’s surface should be waterproof [5]. Over 450 million tons of the paper has been generated yearly in the world, there is prediction that the paper demands are going to be over 500 million tons yearly by the end of the year 2020 [6].

2. Materials and Methods

2.1 Materials

a. Cement
Ordinary Portland cement kind one created via (Lafarge Company / Bazian) commercial well-known as Mass has been utilized in this study. Test results regarding the cement showed the fact that cement meets the prerequisites regarding Iraq measurement (No.5/1984) [7]. Furthermore, the tests have been directed at the National center for Construction Laboratories and Researches (NCCLR) in Baghdad.

b. Fine aggregate
Natural sand of zone (2) has been applied as fine aggregate, also it has been obtained from (Al-Ukhaider). The tests have been conducted for determining of the sulfate content, fineness modulus, as well as grading are complying to the requirement of Iraqi specification No.45\ 1984 [8]. Chemical as well as physical tests have been carried out at (NCCLR).

c. Coarse Aggregates
The crushed gravels with 19mm maximum size was utilized in this research as coarse aggregate. It has been carried from Al-Nabaai to the north of Baghdad. The gradation of the used coarse aggregate and its physical and chemical tests have been carried out at NCCLR. Results of the tests indicated that the coarse aggregate as conforming to Iraqi standard requirement No.45\ 1984 [8].

d. Water
Tap water has been applied for washing purposes, blending as well as curing regarding concrete mixes of this search.

e. Wastepaper
Paper can be considered as the major component with regard to papercrete, thus its properties are dependent on the microstructure of paper. In this research was the use of wastepaper (printing paper) as the main material. The wastepaper that utilized in this work was taken from universities. Papers has been cut by cutter paper cut the paper into small pieces were soaking in room temperature water
for three days in water in order prevent the water from absorbing the mixing water when added to the concrete mixes. (Table-1) shows the properties of dry paper. The chemical inspection through EDXRF EDX-7000 regarding papercrete wastepaper is indicated in the (table -2). Figure 1 presents the papercrete’s preparing.

| Table 1. Properties of wastepaper |
|-----------------------------------|
| Moisture Content % | 2.65 |
| Specific Gravity | 0.98 |
| Density(kg/m³) | 0.8 |
| Absorption% | 90 |

| Table 2. The chemical analysis (oxide composition) through (EDX) related to wastepaper papercrete |
|-----------------------------------------------|
| Oxide Composition | Percentage Content % |
| CaO | 71.223 |
| Al₂O₃ | 13.960 |
| Fe₂O₃ | 3.981 |
| SiO₂ | 9.599 |
| SO₃ | 0.107 |
| CuO | 0.089 |
| ZnO | 0.047 |
| SrO | 0.034 |
| K₂O | 0.960 |

Figure 1. Wastepaper pulp’s preparation (a) wastepaper prior to cutting (b) cutting shedder (c) wastepaper following cutting (d) soaking of the wastepaper in water (e) mixing of paper small pieces (f) papercrete
2.2 Proportional mix of concrete
The purpose of a blend design is to have economic proportions for available which complies with the required adequate workability to be placed in mold. The paper pulp has been replaced through cement’s weight of 0%, 5%, 7% as well as 20% for making concrete papercrete with (1:1.60: 2.37) (cement, sand, gravel) ratio via weight, in addition to content of cement (430 Kg/m³) with (w/c) ratio has been 0.48. Various percent ratios that are related to Paper pulp have been specified through batching each one of the blends with replaced cement’s weight (5, 7 and 10%) for producing mixes concrete as can be seen in the (Table -3). The properties that are related to the freshly blended concrete have been specified, also the test samples have been cast to evaluate the concrete’s strength. All percent ratios have been increased of papercrete, 3 cube samples wear studied for the compressive strength, 3 cylindrical samples wear tests with regard to the splitting tensile strength, also 2 prisme with regard to flexural tensile strength at a treatment period of 7, 14 and 28 days. Overall 96 samples have been prepared for the purpose of testing in this study.

| Mix Symbol | Details               |
|------------|-----------------------|
| P-0        | Conventional Mix      |
| P-5        | Conventional Mix+ 5% pulp |
| P-7        | Conventional Mix+ 7% pulp |
| P-10       | Conventional Mix+ 10% pulp |

2.3 Fresh concrete test, Slump test
Thus, the test has been useful for obtaining the workability with regard to all the types related to the concrete mixtures; the tests has been conducted depending on ASTM C143-12 [9]. The metallic slump molds utilized for each one of the mixes. slump test workability regarding all the concrete mixes has been indicated through slump test. Hardened concrete test,

a. Compressive Strength
The measurement that is related to the concrete compressive strength has been conducted, through machine of digital compression which has capacity of (2000KN) (Controls machine), depending on British Standard BS 1881 part 116 [9] applying cubical samples having the size of (100 * 100*100) mm, as well as taking the average results regarding 3 samples at 7, 14 and 28 day age for each one of the mixes.

b. Split Strength
The measurement regarding the concrete split strength has been carried out, through a machine of digital compression which has capacity of (2000KN) (Controls machine), depending on ASTM C496 [10] with the use of 100*200 mm cylindrical samples as well as the load has been utilized continuously up to failure. The average result regarding 3 cylinders has been evaluated at 7, 14- and 28-days age fir each one of the mixes.

3. Flexural tensile Strength
Such property will be specified depending on (ASTM C-78 [11]. The specimens have been put to test at a period of 7, 14, as well as 28 days. The average regarding 2 samples in all ages has been assumed. The prisme samples having dimensions has been utilized with length, width, as well as height of (400mm*100mm*100mm).

3. Results and Discussion
Results that are related to the slump values regarding each one of the concrete mixtures as can be seen in the figure 2. Slump test will be decreasing with increasing the wastepaper pulp content because of cement absorbed less than water when compared with paper pulp and so reducing the workability of concrete mixture.
The advancement regarding the compressive strength related to conventional concrete, different percent ratios regarding paper pulp which study as partial replacement regarding cement with treating can be seen in the Figure 3. The result indicated the increase in compressive strength with curing process due to the process of hydration process remains till acquiring concrete’s complete strength, yet when applying pulp paper as cement’s partial replacement, showed be reduced in compressive strength less than normal concrete apart from the mix with 5% regarding papercrete replacement. A mixture with (5%) appearances fairy high in comparison to the normal mixture, due to the waste paper contents sensible content regarding alumina-siliceous material which has been joined with Ca, resulting in strength’s enhancement. The strength advancement related to the strength has been majorly inferable to hydraulic and pozzolanic activity related to the wastepaper which is activity through alkalis and a few, Ca(OH)₂ that has been released from the process of hydration.
The test results regarding the conventional concrete and three percent ratios of paper pulp as cement’s partial replacement in concrete at ages (7, 14 and 28) days as shows in figure 4, respectively. The result appeared decrement in split strength less than normal concrete except that mix with 5% of papercrete replacement. This is due to loss in cohesion as well as binding related to the calcium-hydrate-silicate (C-S-H) gel on cellulosic material has been very weak. In addition to the adding wastewater to concrete blend is going to hold volume in samples and any expansions is going to be weakening the concrete.

![Figure 4. Results of Splitting tensile strength](image)

Such property for conventional concrete without any replacement, and percent ratios of paper pulp at ages (7, 14 and 28) days shown in figure 5. It is showed that the bending strength. The result appeared reduction in flexural tensile strength less than normal concrete apart from the mixture with (5%) regarding the paper pulp replacement. There will be a reduction in the strength with increasing paper pulp. This conclusion agrees with other researchers such as Cherian et al (2016) [12], Sourabh et al (2018) [13-15].

![Figure 5. Results of Flexural tensile strength](image)

4. Conclusions
According to the above-mentioned results, there is an impact of the pulp wastepaper on concrete’s mechanical properties. Where compressive strength appeared reduction in compressive strength less than normal concrete apart from the mixture with (5%) regarding the paper pulp replacement at (28 days) of curing age. Also, splitting tensile strength as well as the flexural tensile strength show decrease in the flexural strength as well as the splitting strength less than the normal concrete apart from the mixture with (5%) regarding paper pulp replacement. Furthermore, slump test will be decreased with the increase in wastewater pulp’s percentage. Workability related to the concrete mix has been reduced with the increase in pulp wastepaper amount. In addition to using pulp wastepaper in concrete is inexpensive since it is considered to be free of costs as well as non-useful waste. Furthermore, using pulp wastepaper in the concrete is going to preserve certain natural resources which might be utilized for the production of cement, therefore producing concrete building industry which is sustainable for partial cement replacement and thus it was full solved disposal problem regarding the paper industries for such waste materials.

References
[1] Jayeshkumar P, Zala L B, Umrigar F S, 2013, *Int. J. Adv. Eng. Technol.* IV(I) 31.
[2] Srinivasan R, Sathiya K, Palanisamy M, 2010, *Bul. Ins. Politeh. Din. Last. Sect.Constr. Arhit.* 56(1) 43.
[3] Iqbal N, Gorgis M, Harith Z, Shakir A, 2017, *ARPN J. Eng. Appl. Sci.* 12(24) 25.
[4] Aciu C, Ilutiu D A, Cobirzan N, Balog A, 2014, *Int. Con. Int. in Eng.* 295.
[5] Zaki H, Gorgis I, Salih S, 2018 *MATEC Web of Conferences* 162 02016.
[6] Hashmi A, H.N. & N. Baig, 2013, *Int. J. Eng.* 11 337.
[7] Central Organization for Standardization and Quality Control, “Portland Cement”, Iraqi Specifications Measurement No. 5 (1984).
[8] Central Organization for Standardization and Quality Control, “Utilization of Natural Aggregate Source”, Iraqi Specifications Measurement 45. (1984)
[9] ASTM C 143-03, “Standard Test Method for Slump of Hydraulic- Cement Concrete”, ASTM International, Annual Book of ASTM Standards, American Society for Testing and Materials, V. 04-02, pp.1-4, United State, (2007).
[10] Methods for Determination of Compressive Strength of Concrete Cubes, British Standard Institution, 1881: Part 116, (1989).
[11] ASTM C-496, “ Standard Test Method for Splitting Tensile of Cylindrical Concrete Specimens”, Annual Book of ASTM Standards, American Society for Testing and Materials, Vol. 04-02, pp. 1-6, (2007).
[12] ASTM C78-04, “Standard Test Method for Flexural Strength of Concrete”, Annual Book of ASTM Standard, Vol. 04-02, (2004).
[13] Cherian V, Jefin P J, Neema V N, Namitha, 2016, *J. Int. Res. J. Eng. Technol.* 3(5) 2395.
[14] Raghuvanshi S, Singh V V, Mishra P, 2018, *Int. J. Sci. Res. Dev.* 5(12).
[15] Al Zubaidi A B, N. M. A. K. Nasser, 2018, IOP Conf. Series: Materials Science and Engineering 012035.