

Study of the Effect of Recycled Ash Wastepaper on the Mechanical Properties of green Concrete

Aseel B. al Zubaidi^{1*}, Nahedh M. Ali¹, Afrah K. Nasser¹

¹Department of Materials engineering, university of Technology, Baghdad, Iraq.

*Corresponding Author: dr.material@yahoo.com

Abstract: The Waste materials need to be recycled in some method to avoid ground contamination. One of the methods to reuse such materials is to include in concrete materials. This will decrease pollution and encourage sustainable development in environment conservation. In this work ash wastepaper was partially replaced as 0%, 5%, 7% and 10% in place of cement in concrete for M-25 mix (i.e. concrete design mix of 1: 1.60 : 2.37 cement , sand and aggregate as per ASTM C 94 : 2007) with 0.48 w/c ratio was used. About 4 mixes with ash wastepaper were prepared. Strength properties were determined by compressive strength, splitting tensile strength and flexural tensile strength at (7, 14 and 28) days. From The results showed that the replacement of ash wastepaper increases the compressive strength and splitting tensile strength and flexural tensile strength by (22.129%) , (4.160%) and (34.783%) respectively, at (28) days of curing when (5%) of ash wastepaper was added by weight.

Keywords: Ash wastepaper, compressive strength, splitting tensile strength, flexural tensile strength

1. Introduction

Normal concrete is responsible for amount of carbon-dioxide emission to some extent. In addition to this the Portland cement is the one of the main ingredients in the manufacture of many building materials include concrete composites. So to decrease the emission, various kinds of concrete are developed using waste materials like wastepaper which requires low amount of energy as well as cause least harm to the environment. This research is aimed to study the addition of ash wastepaper to concrete mix, to study the effect of ash wastepaper on mechanical properties such compressive strength, splitting tensile strength and flexural tensile strength of concrete. Ash wastepaper has been used as building materials for decades , especially in cementitious matrices, and since then a lot of researches has been conducted to develop the mechanical properties of the composite such compressive strength, splitting tensile strength and flexural tensile strength. Determined the optimum percentage replacement of cement with wastepaper sludge ash (ash wastepaper industry). The results show that the optimum replacement percentage was found to be 5% (Sajad et al , 2013) [1].The utilization of this type of waste material as a replacement of cement with specific percentage led to decrease the cost of using cement as well as to produce concrete with less environmental impact with low cost of using of production. The waste paper sludge ash was partially replaced as 5%, 10%, 15% and 20% in place of cement in concrete for M-15 mix (i.e. concrete design mix of 1:2:4 cement, sand and aggregate as per IS 456:2000) and tested for its mechanical properties . The results show that , it is found that wastepaper sludge ash can be used as cement replacement up to 15% by weight and particle size less than 90 μ m to prevent decreasing in workability (Yousuf et al ., 2014) [2].



2. Research Significance

Investigation of using of paper waste as addition material in concrete mixes to be utilized for various construction projects, ensuring that the resulting concrete has proper compressive strength as well as to find basic characteristics of the concrete such as compressive strength, splitting tensile strength and flexural tensile strength, and comparison of results of various characteristics with conventional concrete.

3. Experimental work

3.1 Material used:

3.1.1 Cement Ordinary Portland cement (Type 1) manufactured in Iraq by (Lafarge Company / Bazian) commercially famed as (Mass) was used throughout of the work. The chemical composition and main compounds of cement are explained in (Table-1). The test results of cement present that the cement meeting the requirements of Iraq specification (No.5/1984) [3]. Tests were carried out by National center for Construction Laboratories and Researches (NCCLR).

Table 1. Chemical composition and main compounds of ordinary portland cement (OPC)

Oxide composition	Abbreviation	% by weight	Limit of IQS No.5\1984
Lime	CaO	64.6	
Silica	SiO ₂	20.63	
Alumina	Al ₂ O ₃	5.4	
Iron oxide	Fe ₂ O ₃	3.65	
Magnesia	MgO	0.7	≤ 5%
Sulphate	SO ₃	2.4	≤ 2.8%
Loss of Ignition	L.O.L.	2.55	≤ 4%
Lime saturation factor	L.S.F.	1	0.66-1.02
Insoluble residue	I.R.	0.9	≤ 1.5

3.1.2 Coarse aggregate. Crushed coarse aggregate was used as coarse aggregate through the experimental work. It was tested to determine the sieve analysis, in addition to physical and chemical properties of gravel as shown in Table 2. The tests results were presented the gradation of the gravel which are within the requirements of the Iraq specification No. 45/ 1984 [4]. Tests were carried out by National center for Construction Laboratories and Researches (NCCLR) in Iraq.

Table 2. properties of Coarse Aggregate

Properties	Tests Results	Limit of IQS No.45\1984
Specific gravity	2.6	-
Sulphate content	0.023%	< 0.1%
Water absorption	0.8%	-

3.1.3 Fine aggregate. The fine aggregate used throughout this work was natural sand brought from Al-khaidher region in Iraq. Tests were carried out to determine the grading, fineness modulus, sulfate content and percentage absorption. The results indicated that the grading and sulfate content were within the requirements of the Iraqi specification No. 45/1984 [4]. Tests were carried out by National center for Construction Laboratories and Researches (NCCLR) in Iraq. The grading of fine aggregate is shown in Table 3. Table 4 shows the specific gravity, sulfate content and absorption of fine aggregate.

Table 3. Gradation of fine aggregate

Sieve size (mm)	Percentage passing %	Limit of IQS No.45\ 1984
10	100	100
4.47	96	90-100
2.36	78	75-90
1.18	61	55-90
0.6	40	35-55
0.3	16	8-30
0.15	5	0-10

Table 4. Physical and chemical properties of fine aggregate

Properties	Test Results	Limits of IQS No.45\1984
Specific gravity (SSD)	2.5	
Fineness modulus	3.01	
Sulphate content	0.137%	$\leq 0.5\%$
Absorption	1.6	
Clays and Fine material	2.6%	$\leq 5\%$

3.1.4 *Water.* Tap water was used in this research for all mixing and curing process.

3.1.5 *Waste papers.* The printing wastepaper was collected from schools and libraries, and then it burnt by furnace, Burning of wastepaper at 525 C for 60 minute according to ASTM D 586 [5]. Then after burning, the wastepaper pass through sieve No .600 μ m in order to obtain the used wastepaper ash. Ash wastepaper was used as a 5%, 7% and 10% partial replacement of cement weight. The method of prepared ash wastepaper as shown in figure (1). The chemical analysis by Energy Dispersive X-Ray Fluorescence (EDX-7000) of ash wastepaper shown in table 5.

Table 5. Chemical analysis (Oxide composition) by (EDX) of Ash wastepaper

Oxide composition	Percentage content %
CaO	90.993
SiO ₂	4.379
Fe ₂ O ₃	2.689
SO ₃	0.025
K ₂ O	1.829
MnO	0.021
SrO	0.019
TiO ₂	0.043
ZrO ₂	0.002
Loss of Ignition	5.03



Figure 1. preparation of wastepaper ash (a) wastepaper before burning (b) wastepaper after burning, (c) sieving No,600µm of wastepaper ash, (d) ash wastepaper

3.2 Experimental Program And Test Procedures

3.2.1 Proportional mix of concrete. Mix of concrete was prepared by mixing all the ingredients in a mixer. The mix proportions for all mixes were based on weight proportions of M-25 (concrete design mix of 1:160:2.37 cement, sand and gravel as per ASTM C 94: 2007) concrete. The water to cement ratio of 0.48 was adopted. Various proportions of the ash wastepaper were investigated by batching each mix with replaced by “weight of cement with (5, 7 and 10%) to produce “mixtures concrete as it is shown in Table 6. The properties of freshly mixed concrete were determined and test specimens were cast for the evaluation of strength of concrete. For each percentage increment of ash wastepaper, three cube specimens wear tested for compressive strength and three cylindrical specimens wear test for splitting tensile strength and two prisme for flexural tensile strength at 7days , 14 days and 28 days of curing period. A total of 96 specimens we made for the experimentation of this study.

Table 6. Concrete mixes symbols

Mix symbol	Details
FA	Control mix
F-5	Control mix + 5% Ash wastepaper
F-7	Control mix+ 7%Ash waste paper
F-10	Control mix + 10%Ash wastepaper

3.2.2 Fresh concrete test

3.2.2.1 Slump test

A slump test is a suitable test to determine the workability for all types of concrete mixtures; the test was performed according to ASTM C143 [6]. Metallic slump mold used of all mixes, slump test the workability of all concrete mixes was found by slump test. The difference in level between the height of mold and that of highest point of the subsides concrete was measured as shown in figure (2).



Figure 2. Slump Test

3.2.3 Hardened concrete test\

3.2.3.1 Compressive strength

Cubic specimens with dimensions was used with 100mm*100mm*100mm.is according to (B.S 1881:Part 116) [7] . Average compressive strength of three cube specimens was recorded at the age of (7, 14, 28) days.

3.2.3.2 Splitting tensile strength

The splitting strength was done in this research according to (ASTM C-78) [8] and the Average splitting tensile strength of three cylinder specimens was recorded at the age of (7, 14, 28) days. Cylindrical specimens was used with dimensions (100mm) diameter and (200mm) height.

3.2.3.3 Flexural tensile strength

flexural tensile strength is determined according to (ASTM C-496) [9] .The specimens were tested at age of (7,14, 28) days . The average of two specimens in each age was adopted. prisme specimens with dimensions was used with 400mm*100mm*100mm length, width and height respectively.

4. Results and Discussion

4.1 Slump test

The results of the slump values of all the concrete mixtures as shown in figure 3. The slump test decrease with increase in ash wastepaper content. Ash wastepaper particles absorbed more than water as compared to cement and thus decreasing the workability of concrete mixture.

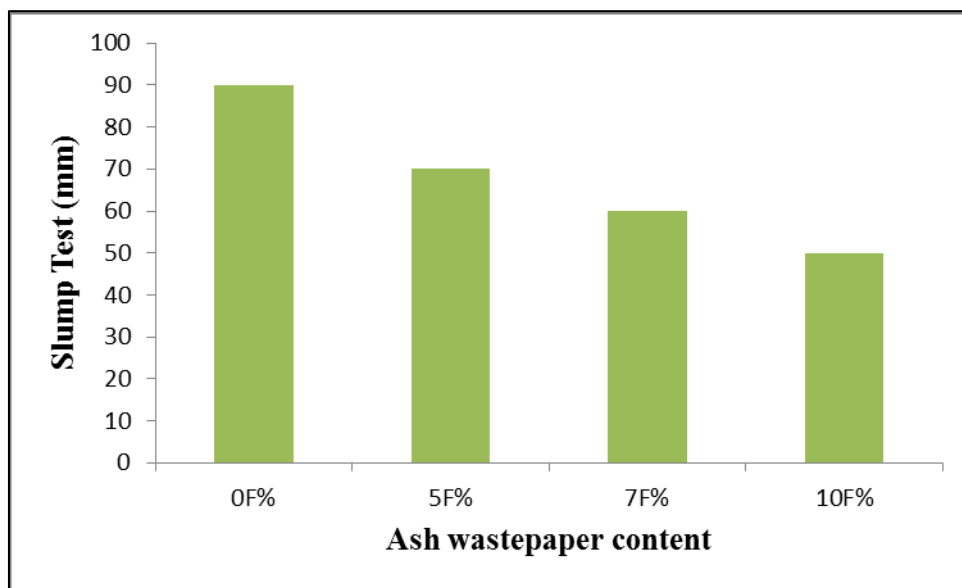


Figure 3. Results of slump test

4.2 Compressive Strength

The test results showed that increase in compressive strength of concrete happened after (28) days of curing time. Figure 4 show the compressive strength results for concrete samples containing different percentage weight of ash wastepaper at the time of (7,14 and 28) days. The test results showed that the increase in percentage weight of ash wastepaper up to (10%) by percentage weight causes an increase in compressive strength up to (22.129 %) in mix (5F) at (28) days compared to the conventional mixes. For mix (7F), which contains (7%) of ash wastepaper, the compressive strength increased by (18.225%) at (28) days of curing time as compared to the conventional mix with (0%) of ash wastepaper. For mix (10F), which contains (10%) of ash wastepaper, the compressive strength increased by (12.49%) at (28) days of curing time as compared to the conventional mix with (0%) of ash wastepaper. For the mixes (5F) , (7F) and (10F) , the compressive strength increased clearly from the first week of test, this increase reached (16.22, 4.12, 1.62 %) for (5%, 7% and 10%) of ash wastepaper at (7) days of curing time. In this kind of concrete, the hydration process leads to shortage of water in the cement paste. At this stage, the water content in particles of ash wastepaper can promote a supply of water internally to the concrete for continuous hydration. These hydration products fill the pores or micro-cracks and improve concrete properties.

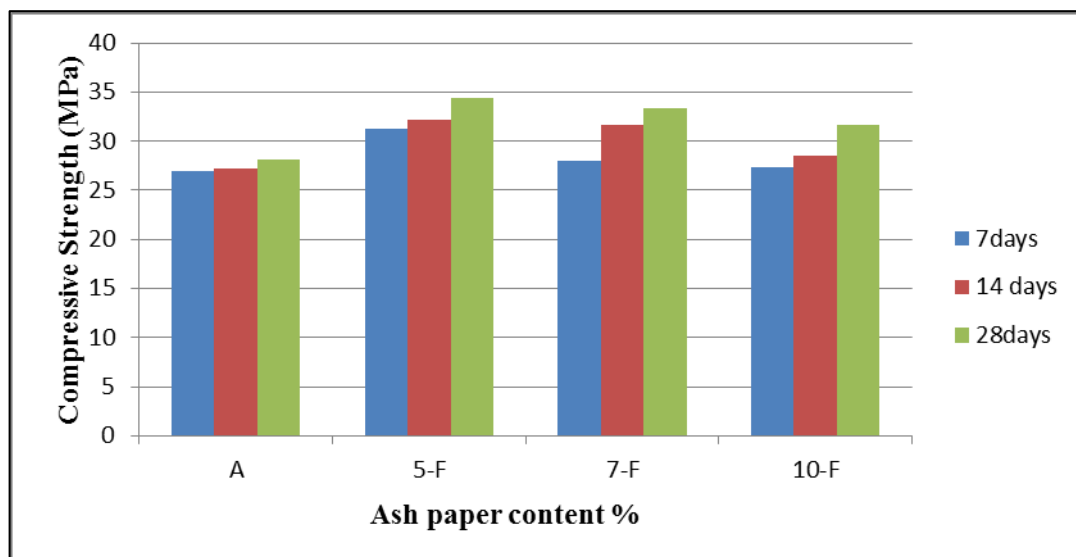


Figure 4. Results of compressive strength of concrete

4.3 Splitting Tensile Strength

The results of the splitting tensile strength of conventional and ash wastepaper modified concrete with curing are presented in Figure 5. The results show that the ash wastepaper modified concrete has splitting tensile strength higher than that of conventional concrete. The splitting tensile strength increases, at all ages, with the increase in the ash wastepaper. The results showed that the splitting tensile strength of the concrete increased as the percentage of the ash wastepaper increased in the mixtures. It was observed that the concrete splitting tensile strength of the cylindrical samples increases with increasing age. The test results showed that the increase in percentage weight of ash wastepaper up to (10%) by percentage weight causes an increase in splitting strength up to (4.160 %) in mix (5F) at (28) days compared to the conventional mixes. For mix (7F), which contains (7%) of ash wastepaper, the splitting tensile strength increased by (0.753%) at (28) days of curing time as compared to the conventional mix with (0%) of ash wastepaper. For mix (10F), which contains (10%) of ash wastepaper, the splitting tensile strength increased by (0.602%) at (28) days of curing time as compared to the conventional mix with (0%) of ash wastepaper.

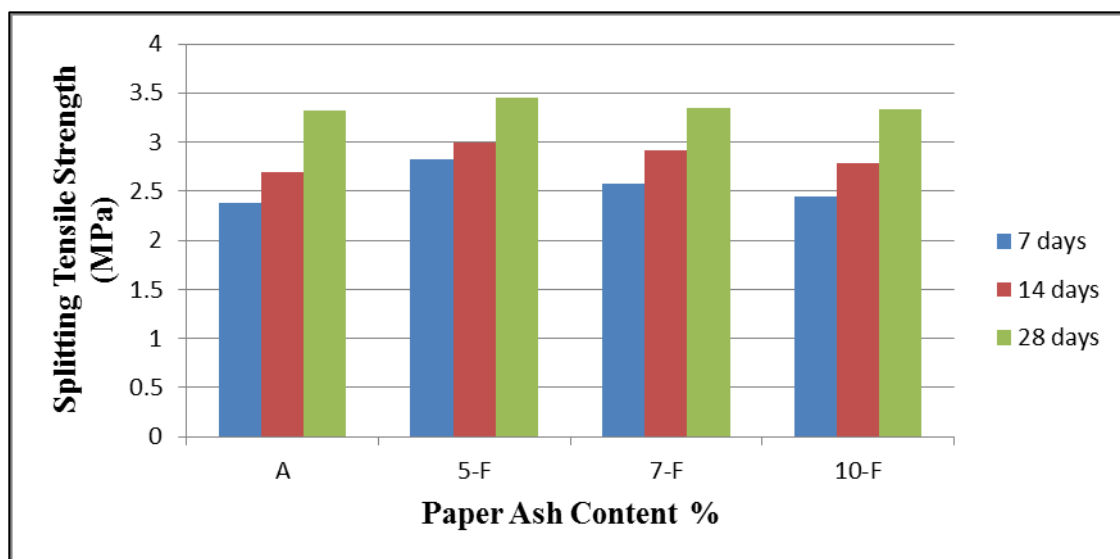


Figure 5. Results of splitting tensile strength

4.4 Flexural Tensile Strength

The results of the Flexural tensile strength of conventional and ash wastepaper modified concrete with curing are presented in Figure 6. The results show that the ash wastepaper modified concrete has Flexural tensile strength higher than that of conventional concrete. The results showed that the flexural tensile strength of the concrete increased as the percentage of the ash wastepaper increased in the mixtures. It was observed that the concrete flexural tensile strength of the prisms samples increases with increasing age. The test results showed that the increase in percentage weight of ash wastepaper up to (10%) by percentage weight causes an increase in flexural strength up to (34.783 %) in mix (5F) at (28) days compared to the conventional mixes. For mix (7F), which contains (7%) of ash wastepaper, the flexural strength increased by (20.217%) at (28) days of curing time as compared to the conventional mix with (0%) of ash wastepaper. For mix (10F), which contains (10%) of ash wastepaper, the flexural strength increased by (0.544%) at (28) days of curing time as compared to the conventional mix with (0%) of ash wastepaper. For the mixes (5F), (7F) and (10F), the flexural tensile strength increased clearly from the first week of test, this increase reached (23.047%, 12.663%, 1.354 %) for (5%, 7% and 10%) of ash wastepaper at (7) days of curing time.

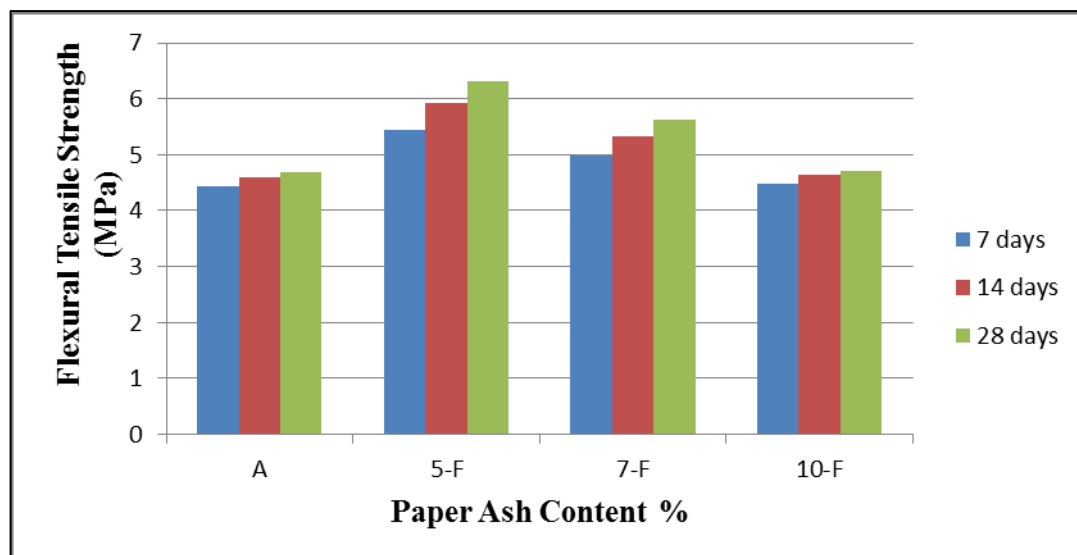


Figure 6. Results of flexural tensile strength

5. Conclusions

Based on the experimentation was carried out on conventional concrete with ash wastepaper replacement 0%, 5%, 7% and 10% cement replacement were prepared with water to cement ratio of 0.48. For all mixes, workability, compressive strength, splitting tensile strength and flexural tensile strength were determined at 7, 14 and 28 days. The following conclusions can be derived from the investigation:

1. The slump test decrease with increase percentage of ash wastepaper, Workability of concrete mix decreases with increase in ash wastepaper content.
2. In general, each group of concrete mixes containing ash wastepaper, compressive Strength, splitting tensile strength and flexural strength of concrete increased with the increase of the amount of ash wastepaper up to (10 %) by weight replacement of cement. The best percentage weight content is (5%) by cement weight. This level of replacement causes a great increase in the compressive strength. This increase reached to (22.129 %) as compared with conventional specimens.
3. Concrete containing ash wastepaper gives better splitting strength as compared with conventional concrete specimens. The splitting tensile strength increases with the increase of percentage weight content. Splitting tensile strength of Specimens that contain ash wastepaper

of (5%) is higher by (4.160%) at (28) days of curing age as compared with conventional concrete specimens.

4. Concrete containing ash wastepaper gives better flexural tensile strength as compared with conventional concrete specimens. The flexural tensile strength increases with the increase of percentage weight content. Flexural tensile strength of Specimens that contain ash wastepaper of (5%) is higher by (34.783) at (28) days of curing age as compared with conventional concrete specimens
- 5- Use of waste paper ash in concrete can prove to be economical as it is non useful waste and free of cost.
- 6- Use of waste paper ash in concrete will preserve natural resources that are used for cement manufacture and thus make concrete construction industry sustainable and waste paper ash can be used as fuel before using its ash in concrete for partial cement replacement and also the disposal problem for paper industries for this waste material is fully solved.

6- References

- [1] Sajad Ahmed, M.Iqbal Malik, Muzaffar Bashir Wani and Rafiq Ahmed 2013 Study of concrete involving use waste paper sludge ash as partial replacement of cement *IQSR Journal of Engineering* , (IOSRJEN) 3, 11 p-ISSN:2278-871.
- [2] Yousuf, Bilal A Adil and Ahmed Rafique 2014 Sustainable use of paper wastes (HYPO SLUDGE) in concrete mix design First international conference on emerging trends in engineering , Management and Sciences, Peshawar, Pakistan.
- [3] Central Organization for Standardization and Quality Control, “ Portland Cement”. Iraqi Specifications Measurement (1984/ No. 5).
- [4] Central Organization for Standardization and Quality Control, “ Utilization of Natural Aggregate Source”. Iraqi Specifications Measurement (1984/ 45).
- [5] ASTM D 586- 97 , " Standard Test Method for Ash in Paper . method A: ash content upon ignition a 525 C . Method : TAPPI T 211 , (2002).
- [6] 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, Vol. 04-02, pp.1-4, United State, (2007).
- [7] B.S 1881: Part 116, “Methods for Determination of Compressive Strength of Concrete Cubes”, British Standard Institution, (1989).
- [8] 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).
- [9] ASTM C78-04. “Standard Test Method for Flexural Strength of Concrete”, Annual Book of ASTM Standard, Vol. 04-02, (2004).