EFFECT OF WASTE PAPER ASH ON THE STRENGTH OF CONCRETE

A Thesis of **Master of Science** By

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THESIS ACCEPTANCE CERTIFICATE

This is to certify that the thesis titled

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Submitted by

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has been accepted towards the partial fulfillment of the

requirements for the degree of

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DEDICATION

I dedicate this work to my family

ACKNOWLEDGEMENTS

All praise for Almighty Allah, the most merciful and more benign; Who made me able to complete this research work. The completion of this project was only possible due to unlimited blessings of almighty Allah because nothing is possible without his will.

Countless salutations are upon the Holy Prophet Hazrat Muhammad (SAWW); the source of knowledge; Who has guided the whole world to seek knowledge from cradle to grave and enable us to win honour of life.

I deem it my utmost pleasure to express the heartiest gratitude to my family members for their regular support, love, sincerity and countless prayers for my glorious success, especially my Mother.

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It will be justice here if I say that most of lab work credit goes to my worker AmanUllah; who really helped me in casting and testing of concrete samples. Many many thanks to him.

Finally, I greatly appreciate all the help from my friends and colleagues who always been so supporting and motivating throughout the process.

UNDERTAKING

I certify that research work titled **"*effect of waste paper ash on the strength of concrete" is*** my own work. Where the material has been used from other sources, it has been properly acknowledged / referred.

Signature of Student: _____

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ABSTRACT

The two challenging tasks for a civil engineer in the field of concrete technology are the strength and economy of the concrete. It is required to get maximum strength of concrete with least expenses. In this study waste paper ash was incorporated in concrete to achieve the task. Paper ash was incorporated in three different ratios of 3%, 6% and 9% as a replacement for cement. The results were obtained at 7 and 28 days. The results show that the compressive strength, tensile strength and flexural strength increased by replacing cement with paper ash up to 6%, but reduced on 9% paper ash replacement. The comparisons with the control samples at 28 days indicated that compressive strength increased by 10.76%, split tensile strength increased by 6.36% and flexural strength increased by 7.63%. The results demonstrate that paper ash collectively improve all the strengths effectively especially the compressive strength. The approach used in current study can be used effectively to utilize the waste material for cleaner environment along with a good quality concrete.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABRIVATIONS

ASTM	American Society for Testing Material
ACI	American concrete institute
KN	kilo Newton
MPa	Mega Pascal
Psi	Pound/inch^2
Mm	Millimeter
SSD	Saturated Surface Dry
W/C	Water to cement ratio
%	Percentage
C.A	Coarse Aggregate
F.A	Fine Aggregate
UTM	Universal Testing Machine
OPC	Ordinary Portland cement
FN	Fineness
SG	Specific gravity
WA	Water absorption
BD	Bulk density
SA	Sieve analysis

CHAPTER-1

INTRODUCTION

1.1 General:

Concrete is that material which is most widely used in construction all over the world. It is generally obtained through mixing binding material (cement) along with fine aggregate, coarse aggregate and water. It is estimated that the present world consumes about 11 billion metric tons of the concrete per year. This is so because concrete has good load bearing capacity and can mould to any shape during casting. It has an appreciable compressive strength and takes compressive load effectively. Another reason for a large use of concrete that it posses good resistance to the water. It withstands to the action of the water without any serious damage and deterioration.

Such a heavy use of concrete can result in depleting the resources of cementitious material. The resources of cementitious material is depleting day by day in current world. So it became an alarming threat to engineer. Thus it is a need of the day to discover any other alternate way for cementitious materials that it can be replaced by any other material. But it should not be expensive because cost is also a key factor for an engineer. And also it should not affect the strength. The two main factors that are important in concrete technology are economy and strength. Concrete technology does not compromise of these two factors. So an alternate way for cementitious material should be economical and should not reduce strength of concrete.

Waster paper ash is can be efficiently mixed inconcrete mix as a substitution of binding material. Paper became a raw material after third recycling in paper industry. The sticky and fibrous nature of paper diminishes with recycling, and after 3rd cycle, it has no fibrous ability, thus it became a raw material. The chemical composition of waste paper ash contains calcium, silica and aluminum that coincide with cement and the particle size of waste paper ash is also very small. Thus waste paper ash can

be an alternate way for cementitious material and can be easily used in concrete. As discussed that waste paper is a raw materials that pollutes the environment. So, the efficient way of waste paper helps in a cleaner environment productive solution for raw materials.

Keeping in view the above discussion, waste paper ash was used in concrete in this thesis and various strength tests were conducted to investigate the strengths. This replacement of waste paper ash is helpful in increasing all the three strengths of concrete (compressive strength, flexural strength, splitting tensile strength), an alternate way in replacement of cementitious material and also good for cleaner environment.

1.2 Problem Statement:

The focusing point of a civil engineer during any project is strength and economy of the structure. In this research the strength and economy can be achieved by incorporation waste paper ash. So the research is helpful in making an effective and efficient concrete. This research is also helpful in using the raw material in efficient way makes the environment clean and healthy. Thus it is good to use a raw material in more productive way.

1.3 Objectives:

The point of interest of the research work is to minimize the cost of the concrete and increase the strengths tryingwaste paper ash. The objectives of this work are as under:

- To increase the strength by incorporating the waste paper ash as a substitution of cementitiousmaterial in the concrete mix.
- To minimize the cost of the concrete mix by incorporating the waste paper ash in the replacement of cementitios material.
- To investigate an alternate way for cementitious material.
- To enhance the strength especially the compressive strength by incorporating the waste paper ash.

- To make the environment free of raw materials and use the raw material effectively.

1.4 Methodology:

The methodology followed for the task completion is as under:

- Cylinders of the size 6 inches diameter and 12 inches length were selected for casting the concrete.
- Beams of the size 4*4*12 inches were selected for casting the concrete.
- The control samples of conventional concrete were prepared and tested for the sake of comparison with others cylinders and beams.
- Then the cylinders and beams having 3% of paper ash were prepared and tested.
- Then the cylinders and beams with varying percentage of paper ash were prepared and tested.
- The remaining module is kept constant except the replacement of paper ash.
- The entire specimens were casted for both the tests which are at the age of 7 and 28 days.

1.5 Relevance to National Needs:

The enhancement of capacity of concrete is a basic need for an engineer. The use of waste paper ash can achieve this very task effectively with least amount. Waste papers are raw material which can be effectively adjusted in concrete and good for cleaner environment. This way an engineer can enhance the mechanical properties of concrete with least possible amount and can use raw material in better way and make the environment cleaner.

1.6 Thesis Outline:

- Chapter 1 comprises the brief description about the research topic and the admixtures used in the project. This chapter tells about the

importance and need of the project according to relevance to national need.

- Chapter 2 describes the literature review about the topic of the research. The relevant discussion about paper ash is included in this chapter. Besides these an overview is also given about any other ash used in the concrete.
- Chapter 3 consists of the materials used in mix, mix proportions, and tests conducted on the materials and samples. This chapter tells about how the materials are prepared, processed and used in concrete. And also show a description about the casting of concrete sample. This chapter also includes the statistics about the production of paper in Pakistan.
- Chapter 4 includes results and their analysis. All the results are compared with the control sample and their percent increase and decrease are discussed in this chapter.
- Chapter 5 consists of conclusion and recommendations based on the research work.

CHAPTER-2

LITERATURE REVIEW

(Ahmad, Malik et al. 2013) performed experimentally on concrete using ash of waste paper sludge in concrete as asubstitution of cement. The particle size of paper ash was 90 micron. Tests were performed by replacing the ash of paper sludge in concrete mix with having ratio of 5, 10, 15 and 20 percent to the total weight of cement content. The W/B ratio was kept constant through experiment that was 0.45. The results were compared with concrete having zero percent of paper sludge ash. It reveals that the slump was slightly decreased on 5% replacement and then the decrease continued. The compressive and split tensile strength was increased on 5% replacement and then decreased on further replacement of paper sludge ash.

The 28 days compressive strength increased by 15.21% on the replacement of 5% paper ash and started decreasing on further increase of paper ash. Similarly the 28 days split tensile strength enhanced by 5.49% on the replacement of 5% paper ash and started decreasing on further increase of paper ash. And the result further reveals that water absorption was increased as the paper sludge ash was increased, thus it enhances durability of the concrete.

(Bui, Hu et al. 2005) exploredand investigated the effect of rice husk ash on the strength of concrete by partial replacement of the ash of rice husk in the mix. This ash is a highly pozzolanic material that can easily enhance the strength of the concrete and helps in achieving high strength concrete which is a need to modern world. In this study only compressive strength was investigated.Two different types of ordinary Portland cement were used. Rice husk ash was produced by the process of combustion process and then pulverized by vibrating ball mill. Nephthalene based superplasticizer is used for proper workability. The ash was incorporated in the mix as a substitution of OPC in three different percentages that are 10%, 15% and 20% by mass. Tests were carried out on three different values of W/B ratios that were 0.30, 0.32, and 0.34. The slump value decreases as the content of rice husk ash

increases. The compressive strength increased till 20% substitution of the ash but started reduction on further increase.

The 28 days compressive strength was increased on 10%, 15% and 20% of incorporation of rice husk ash in comparison with control sample. When the W/C ratio was 0.30, then the compressive strength at 28 days was increased by 14.54%, 18.27% and23.15% respectively for 10, 15 and 20 percent of incorporation of rice husk ash as a substitution of cement. When the W/C ratio was changed to 0.32 then the compressive strength at the age of 28 days was increased by 15.44%, 21.14% and 21.98% respectively for 10, 15 and 20 percent of incorporation of rice husk ash as a substitution of cement. When the W/C ratio was changed to 0.34 then the compressive strength at the age of 28 days was increased by 10.03%, 16.06% and 19.69% respectively for 10, 15 and 20 percent of incorporation of rice husk ash as a substitution of cement.

The 7 days strength also increased in the same as of 28 days strength. W/C ratio of 0.30, the 7 days compressive strength increased by 13.06%, 16.60% and 19.96% respectively for 10, 15 and 20 percent of incorporation of rice husk ash as a substitution of cement. WhenW/C ratio was changed to 0.32 then the 7 days compressive strength was increased by 13.73%, 20% and 21.18% respectively for 10, 15 and 20 percent of incorporation of rice husk ash as a substitution of cement.Again when the W/C ratio was increased to 0.34 then the 7 days compressive strength was increased by 14.06%, 15.66% and 18.67% respectively for 10, 15 and 20 percent of incorporation of rice husk ash as a substitution of cement.

(Chao-Lung, Le Anh-Tuan et al. 2011)accomplished experiment on the incorporation of rice husk ash (RHA) to concrete and calculated its outcome on the durability and strength of the concrete. Rice husk ash is used for the purpose of pozzolanic activity. The mean particle size of RHA used was 12 microns. RHA was incorporated in the concrete mix in different percentage as a replacement of cement. These percentages are 10%, 20% and 30%. The cement used in the experiment was OPCmanufactured by Taiwan Cement Company. The maximum size of Crushed coarse aggregate was 19

mm.The fineness modulus (FM) of sand was 3.0. To get the desired workability Type G superplasticizers was used. The W/C ratio was kept different in casting different samples. It was 0.26, 0.35, 0.39, 0.44, 0.50 and 0.52 for different samples. The W/B ratio was also kept different. It was 0.23, 0.35 and 0.47. Tests for compression were performed at the age of 1, 3, 7, 14, 28, 56, and 91 days and results were obtained.

The compressive strength at the age of 28 days increased by 8.98% when 10%of RHA was incorporated in the concrete mix although the W/C ratio for control sample was less than 10% rice husk ash sample. The W/C ratio for control sample was 0.35 and it was 0.39 for 10% RHA sample. And when 20% of RHA was incorporated to the mix, the strength again increased by 7.14% from the control sample. In this mix the W/C ratio was 0.44. On further incorporation of RHA to the mix, the strength decreased. The sample having 30% of RHA in the substitution of the OPC has 3.57 percent less strength than control sample, but the W/C ratio in 30% RHA sample was 0.50.

(Balwaik and Raut 2011)performed on experiment by introducing waste paper pulp in concrete in difference ratios. The paper pulp replaced the cement content in different percentage of 5%, 10, 15 and 20 percent. The cement used was 53 grade Portland pozzolanic cement. The coarse aggregates (CA) used were crushed stone.The maximum size of CA was 20 mm and minimum size was 12.5 mm. The specific gravity was2.67 and 2.61 for coarse and fine aggregates respectively. The experiment was performed on two different W/C ratios that were 0.45 and 0.50.

Results reveal that the concrete slump was increased on the replacement of paper pulp by 5% of cement content for both W/C ratios. Above 5% of replacement of paper pulp the slump value was decreased till 20% of replacement.

When tests were performed on hardened concrete, it reveals that the compressive, flexural strength and splitting tensile were increased upto 10

percent of paper pulp substitution. The further increase of the paper pulp in the concrete mix decreased all the strengths.

The compressive strength at 28 days was enhanced by 7.27% and 2.21% respectively on the replacement of 5% and 10% of paper pulp by cement for 0.50 W/C ratio. Thefurther increase in the incorporation of paper pulp decreased the compressive strength. The reduction was 19.60% and 31.65% respectively for 15% and 20% of paper pulp.

The 28 days splitting tensile strength was enhanced by 5.84% and 0.73% respectively on the replacement of 5% and 10% of paper pulp by cement for 0.50 W/Cratio. The further increase in the incorporation of paper pulp decreased the split tensile strength. The reduction was 14.96% and 19.71% respectively for 15% and 20% of paper pulp.

The 28 days flexural strength was increased by 15.20% and 3.66% respectively on the replacement of 5% and 10% of paper pulp by cement for 0.50 water to cement ratio. On further increase of paper pulp, the flexural strength was decreased. The reduction was 12.60% and 25.28% respectively for 15% and 20% of paper pulp.

Similarly the compressive strength of 28 days was enhanced by 4.10% and 2.85% respectively on the replacement of 5% and 10% of paper pulp by cement for 0.45 W/C ratio. The further increase of paper pulp decreased the compressive strength. The reduction was 5.63% and 14.32% respectively for 15% and 20% of the incorporation of paper pulp.

The splitting tensile strength of 28 days was enhanced by 8.82% and 5.88% respectively on the replacement of 5% and 10% of paper pulp by cement for 0.45 W/Cratio. On further increase of the incorporation of paper pulp, the split tensile strength was decreased. The reduction was 5.88% and 17.65% respectively for 15% and 20% of paper pulp.

The 28 days flexural strength was increased by 7.27% and 1.73% respectively on the replacement of 5% and 10% of paper pulp by cement for 0.45 water to cement ratio. On further increase of paper pulp, the flexural strength was decreased. The reduction was 14.96% and 30.39% respectively for 15% and 20% of paper pulp.

CHAPTER-3

METHODOLOGY

3.1 Introduction:

To proceed the experiment ahead, all the materials, testing machines and all calculations regarding it are first concentrated. This chapter includes the discussion on all the materials used in preparing the concrete, mix proportion of concrete, calculation for the usage of different percentage of paper ash and selection of the cylinders and beams and calculating their volumes. It also contains an overview about the tests on hardened concrete in testing machines. The detail is as under;

3.2 Cylinder:

Cylinder is selected for the testing of compressive and splitting tensile strengths. The cylinder selected for the experiment is having diameter of 6 inches and height of 12 inches. Its volume is calculated as;

$\text{Area} = \pi/4 \times d^2$

$\text{Area} = \pi/4 \times 6^2 = 28.274\ in^2$

$\text{Volume} = H \times \text{Area}$

$\text{Volume} = 12 \times 28.274 = 339.292\ in^3 = 0.196\ ft^3$

3.3 Beam:

Beam is used for the testing of flexural strength only. So the beam selected for the experiment is rectangular having 4” width, 4” height, 12” length. The volume is calculated as under;

$\text{Volume} = 4 \times 4 \times 12 = 192\ in^3 = 0.111\ ft^3$

3.4 Materials used:

Below is the discussion about all the materials those are used in the experiment.

3.4.1 Paper ash:

Paper ash for the experiment is obtained by burning waste newspapers. The ash produced from the burning process is then categorized in different particle size through sieve analysis. The ash used in the experiment is sieve # 100 passing and sieve # 200 retained. It is because to obtain a specific particle size in between two known ranges that is 75 micron to 150 micron. So the ash consists of maximum particle size of 150 micron and minimum of 75 micron and the average particle size becomes 112.5 micron. The density of the ash is calculated in laboratory which is 228.66 kg/m^3.

3.4.1.1 The Chemical Composition of Paper Ash:

(Ahmad, Malik et al. 2013)explored the behavior of the ash of waste paper sludge and its incorporation in the concrete. The paper is converted to ash and investigated the chemical composition of the ash which is as under;

Table 3.1: Chemical composition of the ash of paper sludge (Ahmad, Malik et al. 2013)

Chemical composition of waste paper sludge ash	
Element	**Percent content**
O	15.83
Ca	14.94
Si	60.57
Al	2.06
Mg	3.59
S	1.07
K	0.16
Fe	0.92
Na	0.22

Figure 3.1: Sample of Paper Ash

3.4.1.2 Paper production in Pakistan:

During the period of 1990 to 1995 over all paper production was raised.The first four years have good increase in production.It was 64.2 thousand tons as in 1990.The continuously increase from 1991 to 1994 was observed. It became 129.3 thousand tons in 1994 that was a good increase. It further increased in 1995 that was 208.4 thousand tons. In 1996 and 1997 the decrease was seen. And then it started increaseagain till year 2000 to the value 284.8 thousand tons. Year 2001 was bad year for paper production and the production was 137.9 thousand tons. Again increase was observed from year 2002 to 2005 up to 167.7 thousand tons. A slight decrease was seen in year 2006 which was 161.7 thousand tons. Then in the years 2007 to 2008, the production was again increased up to 252.5 thousand tons. In 2009 and 2010 a continuous decrease was seen to 185.4 thousand tons.

Table 3.2: Annual paper production and paper board in Pakistan

Annual Production of Paper and Paper Board

Year	Paper Board (000 tons)	Paper (000 Tons)
2000-01	246.3	284.8
2001-02	187.6	137.9
2002-03	228.2	148.0
2003-04	247.9	156.8
2004-05	420.6	163.7
2005-06	476.7	167.7
2006-07	464.7	161.7
2007-08	448.2	192.0
2008-09	449.6	252.5
2009-10(P)	330.7	185.4
Source: http://www.scribd.com/doc/36021911/Paper-and-Board-Industry-Report		

Report on Paper and Board Industry of Pakistan by S. Shabbir & S. Mahmood (Aug, 2010)

3.4.2 Cement:

For the experiment OPC type-1 was used obtained from Kohat cements, which are easily available in market of Pakistan. (Ali 2010) investigated the chemical composition of the OPC which are SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, loss on ignition (LOI), Insoluble residue (IR) and free lime. The percentage of these constituents of Kohat cement is as follow;

Table 3.3: The chemical composition of Kohat cement (Ali 2010)

Oxides	Percentage
SiO_2	20.78
Al_2o_3	5.81
Fe_2O_3	2.99
CaO	62.18
MgO	1.52
SO_3	1.89
LOI	2.31
IR	0.75
Free Lime	0.68

Similarly some other initial tests were performed on cement to find out it's other characteristics.

3.4.2.1 Consistency Test:

Consistency is the ability to flow of freshly mixed cement. This test shows the viscosity of cement paste. It is the lowest amount of water needed to start the chemical reaction in between the water and cement to make a paste. It is required to calculate the amount of water required for other testing like initial setting time and final setting time. Moreover it is important in designing the workability of the concrete. The consistency of the cement was found in laboratory. Its results are mentioned in the table.

3.4.2.2 Initial Setting Time and Final Setting Time:

The term setting alludes to the solidification of plastic cement paste. The beginning of the solidification is known as initial set which shows the time when the paste became unworkable, while the complete solidification marks the final set. The information of the setting time of cement is helpful in determining the time duration to the concrete mix and transporting of concrete from one place to another. ASTM C150 standard specification for OPC requires the initial setting time to be not less than 45 minutes and the final setting time to be not more than 375 minutes as determined by Vicat needle test (ASTM C191).

The initial and final setting time is mentioned in table.

Table 3.4: Initial testing on cement

S #	**Lab Test**	**Values**	**ASTM Specifications**
1	Standard Consistency	26	22-30%
2	Initial Setting Time	90	45 Mnts (min)
3	Final Setting Time	360	375 Mnts (max)

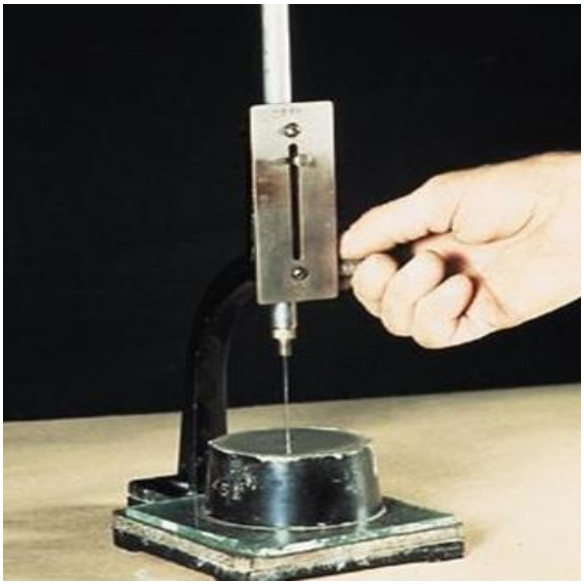

Figure 3.2: Vicat apparatus

3.4.3 Plasticizer:

The plasticizer used in the experiment is Master Rheobuild 830. Master Rheobuild 830 is made from synthetic polymers. Itsmain purpose is to impart rheoplastic qualities to the concrete mix.It is a fluid concrete with a minimum slump of 200mm.It is easily flowing concrete, and also free from segregation and having the same W/C ratio as that of a low slump concrete (25 mm) without admixture.

Properties of the plasticizers are given in table;

Table 3.5: Properties of plasticizer Mater Rheobuild 830

S. No:	**Property**	**Observation / Result**
1	Material	Liquid
2	Colour	Dark Brown
3	Relative Density	1.17 ± 0.02 at 25°C
4	pH	> 6 at 25°C
5	Chloride ion content	< 0.2%

3.4.4 Fine aggregate:

Fine aggregate is acquired from the natural stack available in the every region of Khyber Pakhtunkhwa; Pakistan. The fine aggregate used in concrete in surface dry condition. It was clean and free from any other organic material as per ASTM C33.The fineness modulus (FM) of fine aggregate (FA) was probed in lab and the result is as below;

Table 3.6: Sieve analysis of fine aggregate

Sieve #	**Sieve Size (Inches)**	**Weight Retained (gm)**	**Percent weight Retained (%)**	**Cumulative Percent Retained (%)**	**Cumulative Percent Passing (%)**
# 4	0.187	0	0	0	100
# 8	0.0937	11.3	1.88	1.88	98.12
# 16	0.0469	49.6	8.27	10.15	91.67
# 30	0.0234	220.4	36.73	46.88	53.2
# 50	0.0117	178.5	29.75	76.63	23.43
# 100	0.0059	140.2	23.37	100	
Total		600		235.54	

Fineness modulus = 235.54/100 = 2.35

Other initial tests performed on fine aggregates were the specific gravity and water absorption of the sand. The water absorption calculated in laboratory was 1.34 and the specific gravity was 2.66.

3.4.5 Coarse Aggregate:

Coarse aggregate (CA) is acquired from the natural stack available in the every region of Khyber Pakhtunkhwa; Pakistan. It was down ¾ inches coarse aggregate. The coarse aggregate in concrete was in surface dry condition (SSD) and also was free from any other substance as per ASTM C33.The gradation of coarse aggregate was investigated in lab and the result is as below;

Table 3.7: Grading of coarse aggregate

Sieve #	**Sieve Size (Inches)**	**Weight Retained (gm)**	**Percent weight Retained (%)**	**Cumulative Percent Retained (%)**	**Cumulative Percent Passing (%)**	**ASTM C 33 Passing (%)**
3/4”	3/4	0	0	0	100	90-100
1/2”	1/2	1127	37.57	37.57	62.43	35-80
3/8”	3/8	1045	34.83	72.4	27.6	20-55
#4	3/16	807	26.9	99.3	0.7	0-10
Pan	0	21	0.7	100	0	0-5
Total		3000				

Total sample taken = 3 Kg = 3000 gm

The water absorption test and specific gravity test were also performed on coarse aggregate. The water absorption for coarse aggregate (CA) was 1.65 and specific gravity calculated was 2.73.

3.5 Mix proportion:

Concrete mix ratio of 1:2:4 was opted for the experiment. The W/C ratio selected for mix was 0.45. The amount of all the materials for a single cylinder and a beam is calculated below;

Volume of cylinder = 0.196 ft^3 (calculated above)

Volume of beam = 0.11 ft^3 (calculated above)

Volume of cylinder + Volume of beam = 0.196 + 0.11 = 0.306 ft^3

Total weight of cylinder and beam = Density of concrete × Volume

Total weight of cylinder and beam = 150 × 0.306 = 45.9 lbs = 20.83 Kg

So,

Quantity of OPC = 1/7 × 20.83 = 2.98 Kg

Quantity of FA = 2/7 × 20.83 = 5.96 Kg

Quantity of CA = 4/7 × 20.83 = 11.92 Kg

Now calculating the amount of Paper ash

Paper ash is incorporated in the volumetric replacement of cement to the mix

Calculation for 3% of incorporation of Paper ash:

Density of cement = 1246.22 Kg/m^3 (Calculated in lab)

Density of Paper ash = 228.66 Kg/m^3 (Calculated in lab)

Cement required for single cylinder and beam = 2.98 Kg

Volume of cement for above mass = Mass / Density = 2.98 / 1246.22 = 2.391 * 10^{-3} m^3

= 0.002391 m^3

Now 3% of this volume = 3 / 100 * 0.002391 = 7.173 * 10^{-5} m^3 = 0.00007173 m^3

Mass of 3% volume of cement = Density * Volume = 1246.22 * 0.00007173

= 0.0894 Kg

= 89.4 gm

Thus final amount of cement = 2.98 – 0.0894 = 2.891 Kg

Now incorporating ash on the specified volume of cement

Volume of cement that is to be replaced by ash= 0.00007173 m^3 (Calculated above)

Mass of ash for this volume = Density of ash * Volume

Mass of ash = 228.66 * 0.00007173 = 0.0164 Kg = 16.4 gm

Calculation for 6% of incorporation of Paper ash:

Density of cement = 1246.22 Kg/m^3 (Calculated in lab)

Density of Paper ash = 228.66 Kg/m^3 (Calculated in lab)

Cement required for single cylinder and beam = 2.98 Kg

Volume of cement for above mass = Mass / Density = 2.98 / 1246.22 = 2.391 * 10^{-3} m^3

= 0.002391 m^3

Now 6% of this volume = 6 / 100 * 0.002391 = 1.435 * 10^{-4} m^3 = 0.0001435 m^3

Mass of 6% volume of cement = Density * Volume = 1246.22 * 0.0001435 = 0.179 Kg

= 179 gm

Thus final amount of cement = 2.98 – 0.179 = 2.8 Kg

Now incorporating ash on the specified volume of cement

Volume of cement that is to be replaced by ash= 0.0001435 m^3 (Calculated above)

Mass of ash for this volume = Density of ash * Volume

Mass of ash = 228.66 * 0.0001435 = 0.0328 Kg = 32.8 gm

Calculation for 9% of incorporation of Paper ash:

Density of cement = 1246.22 Kg/m^3 (Calculated in lab)

Density of Paper ash = 228.66 Kg/m^3 (Calculated in lab)

Cement required for single cylinder and beam = 2.98 Kg

Volume of cement for above mass = Mass / Density = 2.98 / 1246.22 = 2.391 * 10^{-3} m^3

= 0.002391 m^3

Now 9% of this volume = 9 / 100 * 0.002391 = 2.152 * 10^{-4} m^3 = 0.0002152 m^3

Mass of 9% volume of cement = Density * Volume = 1246.22 * 0.0002152 = 0.268 Kg

= 268 gm

Thus final amount of cement = 2.98 – 0.268 = 2.712 Kg

Now incorporating ash on the specified volume of cement

Volume of cement that is to be replaced by ash= 0.0002152 m^3 (Calculated above)

Mass of ash for this volume = Density of ash * Volume

Mass of ash = 228.66 * 0.0002152 = 0.0492 Kg = 49.2 gm

The complete amount of all materials for one cylinder and one beam is given in the table;

Table 3.8: Mix proportion

Sample	**Paper Ash (gm)**	**Cement (Kgs)**	**Sand (Kgs)**	**Crush (Kgs)**
Control	0	2.98	5.96	11.92
3% Ash	16.4	2.89	5.96	11.92
6% Ash	32.8	2.80	5.96	11.92
9% Ash	49.2	2.71	5.96	11.92

3.6 Water to cement ratio:

0.45 water to cement (W/C) ratio was selected and was kept constant for all the modules. It was kept constant because of not varying any other parameter except incorporating the paper ash.

3.7 Sample preparation:

After calculating all the materials required for concrete casting, the concrete cylinders having diameter of 6 inches and height of 12 inches and beams having dimensions of 4 inches × 4 inches × 12 inches were casted confirming ASTM C192. Total number of 3 specimens was casted for each module for 7 days. Then the average result of these 3 was taken into account for the sake of precision and accuracy. The same 3 specimens were casted for 28 days also. After casting the specimen were unfastened from moulds after 24 hours time period and were kept in the curing tank.

Table 3.9: Samples Prepared for testing at the age of 7 days

For 7 Days Strength					
Sample	**W/C Ratio**	**Number of Samples**			**Plasticizer**
		Compressive Strength	**Split Tensile Strength**	**Flexural Strength**	
Control	0.45	3	3	3	YES
3% Paper Ash	0.45	3	3	3	YES
6% Paper Ash	0.45	3	3	3	YES
9% Paper Ash	0.45	3	3	3	YES

Table 3.10: Samples Prepared for testing at the age of 28 days

For 28 Days Strength					
Sample	**W/C Ratio**	**Number of Samples**			**Plasticizer**
		Compressive Strength	**Split Tensile Strength**	**Flexural Strength**	
Control	0.45	3	3	3	YES
3% Paper Ash	0.45	3	3	3	YES
6% Paper Ash	0.45	3	3	3	YES
9% Paper Ash	0.45	3	3	3	YES

Figure 3.3: Sample Preparation

Figure 3.4: Sample Preparation

Slump tests were also performed for all the modules on prepared concrete before casting the samples. Slump test shows us the workability of concrete and clarify us about the water content in concrete.

Figure 3.5: Slump Test

All the concrete samples were prepared and the cured for 7 and 28 days respectively. It was observed during casting and after curing too that on incorporation of high percentage of paper ash the colour of concrete became

blackish. And a little honeycombing was also observed on incorporation of high percentage of paper ash.

Figure 3.6: Prepared Sample

Figure 3.7: Prepared Sample

3.8 Testing of the specimens:

After the curing for the required time period the specimen were first tested for the strength at 7 days and then at 28 days.

3.8.1 Compression Test:

To investigate the response of the concrete cylinders for compressive strength or to investigate the crushing capability of concrete cylinder, the cylinders were tested in compression testing machine placing the cylinder in vertical position. The cylinders were tested for strength at the age of 7 and 28 daysrespectively as per ASTM C39.

Figure 3.8: Testing of cylinder for compressive strength

3.8.2 Split Tensile Test:

As the concrete is brittle material and weak in tension, hence it is not expected that it resists the direct tensile load.It develops cracks rapidly when tensile load exceeds its tensile strength. Thus is compulsory to find out the tensile strength of the concrete specimen to find out the load at which the concrete members may crack. So to investigate this strength, the cylinder is kept in compression testing machine in horizontal direction and the load is applied.

The cylinders were tested for 7 days and then for 28 days as per ASTM C496.

Figure 3.9: Testing of cylinder for split tensile strength

3.8.3 Flexural test:

The resistance of concrete in bending is reffered as flexural strength. It is demonstrated in the modulus of rapture. To find out this strength the beams of 4 inches × 4 inches × 12 inches were casted and tested in the two point loading flexural testing machine as per ASTM C293 for 7 days and 28 days.

Figure 3.10: Testing of beam for flexural strength

CHAPTER-4

RESULT AND DISCUSSION

4.1 Introduction:

When the samples were prepared, they were tested in their specified machine after their specified time of curing. This chapter includes the results obtained from compression tests, split tensile tests, flexural test for both 7 days tests and 28 days tests. The results of slump tests are also included here.

4.2 Result of 7 Days Strength:

The results obtained from the average of 3 samples for each of the compressive strength, splitting tensile strength, and flexural strength are discussed below;

4.2.1 Compressive Strength of the Concrete:

The results acquired from the four different samples of the concrete cylinders casted and tested for 7 days compressive strength are presented in fig 4.1, 4.2. It was seen during testing the specimen that the compressive strengthat 7 days increased upto 4.28% and 12.30% by incorporating 3% and 6% paper ash respectively as a substitution of cement to the concrete mix. When the amount of paper ash was further increased to 9% as a substitution of cement, it resulted in the decrease of strength by 8.56%. The results are given in the table 4.1;

Table 4.1: The compressive strength at the age of 7 days

S#	Sample	Strength (Psi)	W/C Ratio	Increase/ Decrease (%)
1	Control sample	2478	0.45	Standard (0%)
2	3% Paper Ash	2584	0.45	4.28
3	6% Paper Ash	2782	0.45	12.30
4	9% Paper Ash	2266	0.45	-8.56

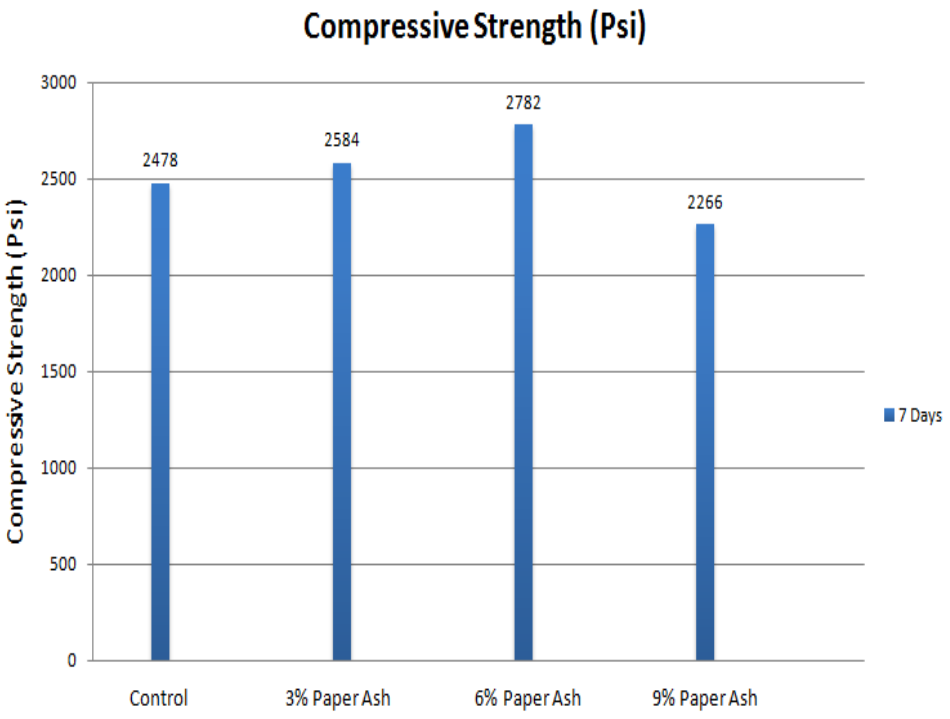

Figure 4.1: Compressive strength at the age of 7 days

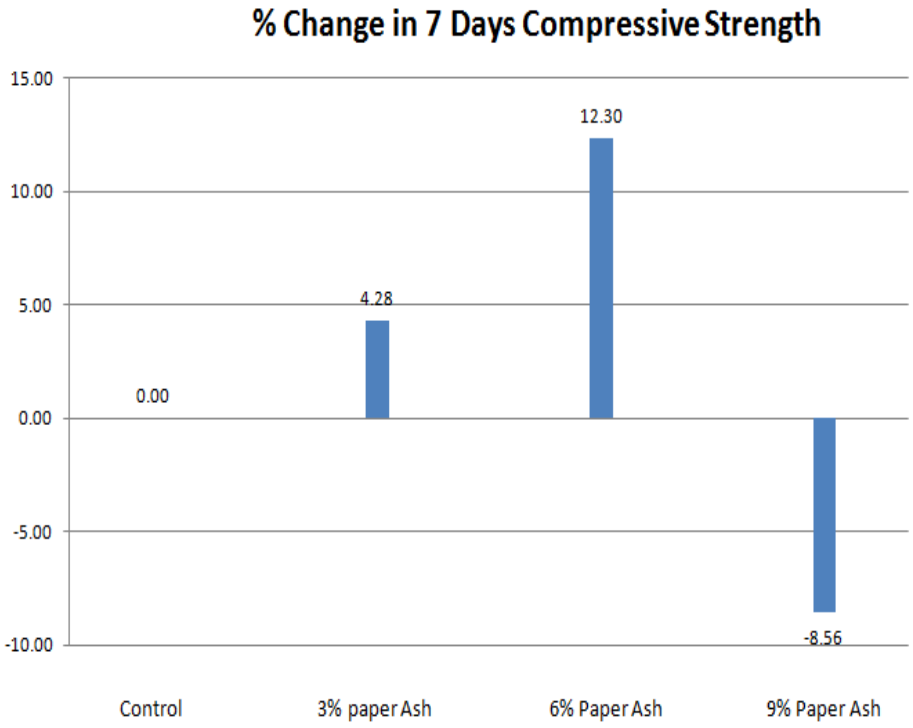

Figure 4.2: Percent change in the compressive strength at the age of 7 days

4.2.2Split Tensile Strength of the Concrete:

The resultsacquired from the four different samples of the concrete cylinders casted and tested at the age of 7 days splitting tensile strength are presented in fig 4.3, 4.4. It was observed during testing the specimen that the splitting tensile strength at the age of 7 days increased upto 3.49% and 8.14% by incorporating 3% and 6% paper ash respectively as a substitution of OPC to the mix. When the amount of paper ash was further increased to 9% as a substitution of OPC, it resulted in the reduction of splitting tensile strength by 5.81%. The results are given in table 4.2;

Table 4.2: Split tensile strength at the age of 7 days

S#	Sample	Strength (Psi)	W/C Ratio	Increase/ Decrease (%)
1	Control sample	285	0.45	Standard (0%)
2	3% Paper Ash	295	0.45	3.49
3	6% Paper Ash	308	0.45	8.14
4	9% Paper Ash	268	0.45	-5.81

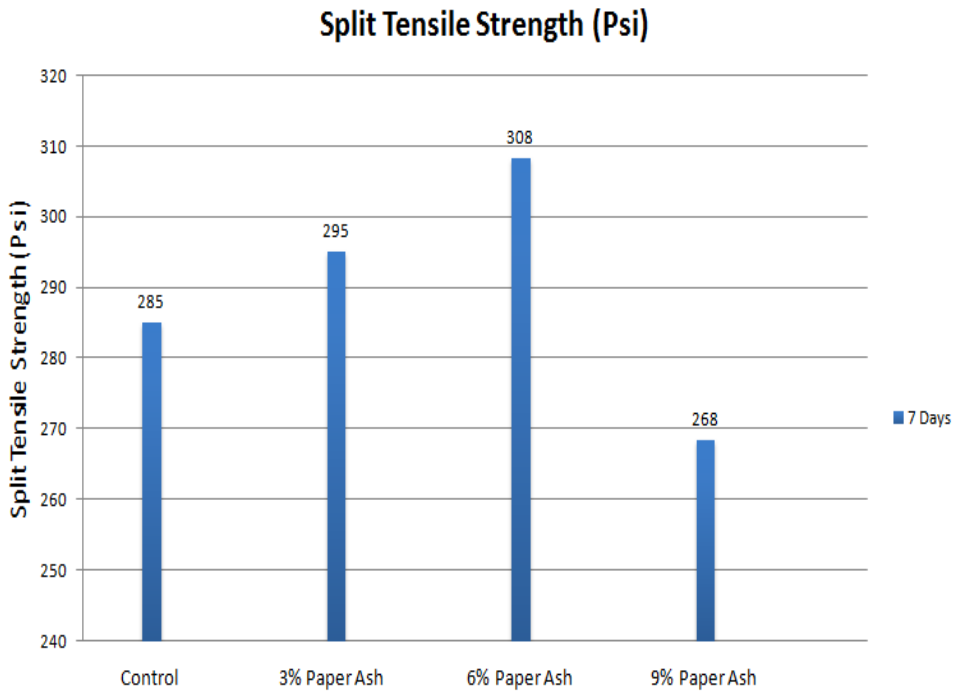

Figure 4.3: Split tensile strength at the age of 7 days

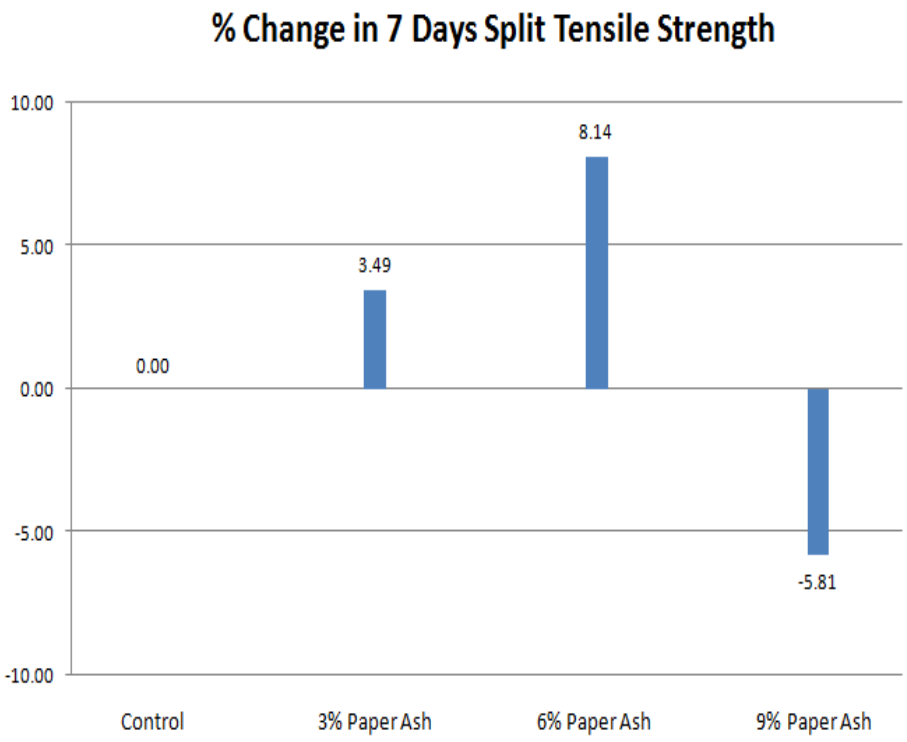

Figure 4.4: Percent change in split tensile strength at the age of 7 days

4.2.3Flexural Strength of Concrete:

The results obtained from the four different samples of concrete beams casted and the tested at 7 days for flexural strength are presented in fig 4.5, 4.6. It was observed during testing the specimen that the flexural strength at 7 days increased upto 3.45% and 7.16% by incorporating 3% and 6% paper ash respectively as a substitution of OPC to the concrete mix. When the amount of paper ash was further increased to 9% as a substitution of OPC, it resulted in the decrease of flexural strength by 11.41%. The results are discussed in table 4.3;

Table 4.3: Flexural strength at the age of 7 days

S#	Sample	Strength (Psi)	W/C Ratio	Increase/ Decrease (%)
1	Control sample	530	0.45	Standard (0%)
2	3% Paper Ash	548	0.45	3.45
3	6% Paper Ash	568	0.45	7.16
4	9% Paper Ash	469	0.45	-11.41

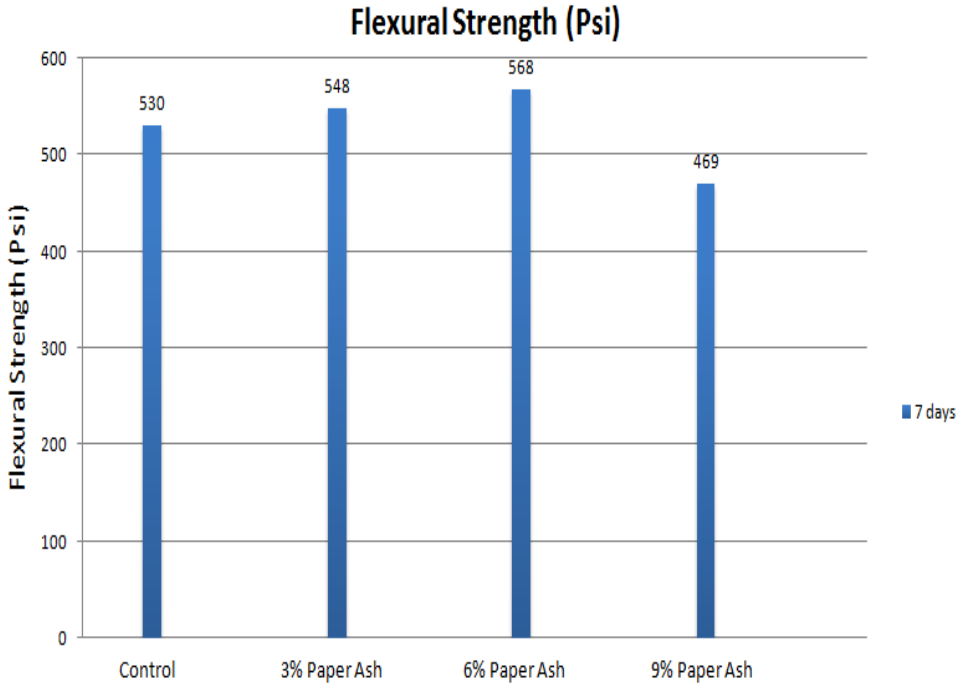

Figure 4.5: Flexural strength at 7 days

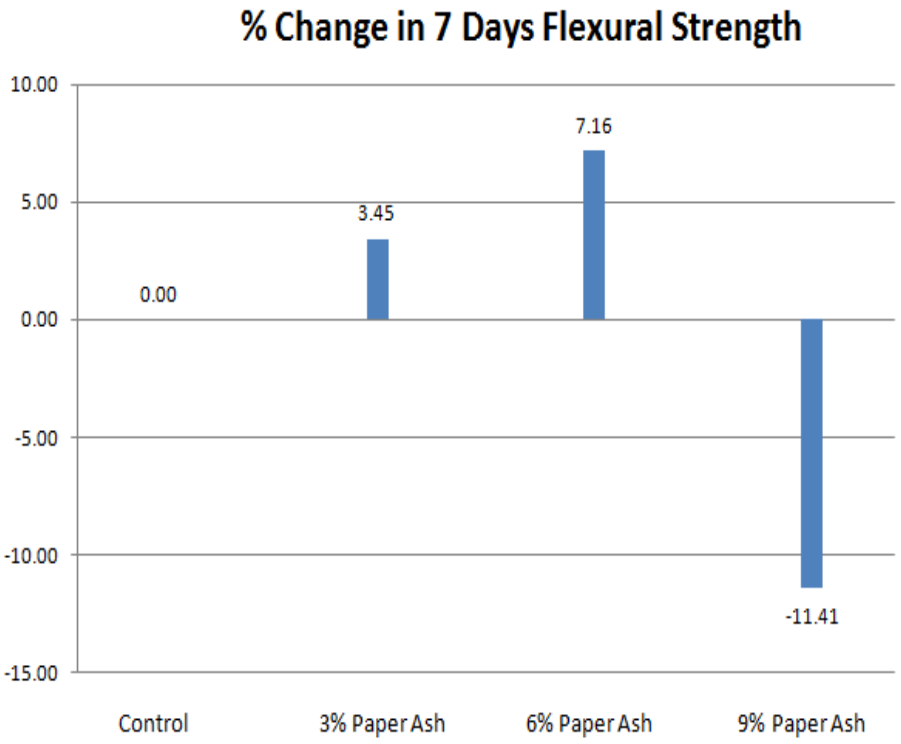

Figure 4.6: Percent change in flexural strength at 7 days

4.3 Result of 28 days Strength:

The results obtained from the average of 3 samples for each of the compressive strength, flexural strength and splitting tensile strength are discussed below;

4.3.1 Compressive Strength of Concrete:

The results obtained from the four different samples of concrete cylinders casted and tested for compressive strength at the age of 28 days are presented in fig 4.7, 4.8. It was seen during testing the specimen that the strength at 28 days enhanced upto 6.77% and 10.76% by incorporating 3% and 6% paper ash respectively as a substitution of OPC to the mix. When the amount of paper ash was further increased to 9% as a substitution of cement, it resulted in decrease of compressive strength by 14.34%. The results are given in table 4.4;

Table 4.4: Compressive strength at the age of 28 days

S#	Sample	Strength (Psi)	W/C Ratio	Increase/ Decrease (%)
1	Control sample	3326	0.45	Standard (0%)
2	3% Paper Ash	3551	0.45	6.77
3	6% Paper Ash	3683	0.45	10.76
4	9% Paper Ash	2849	0.45	-14.34

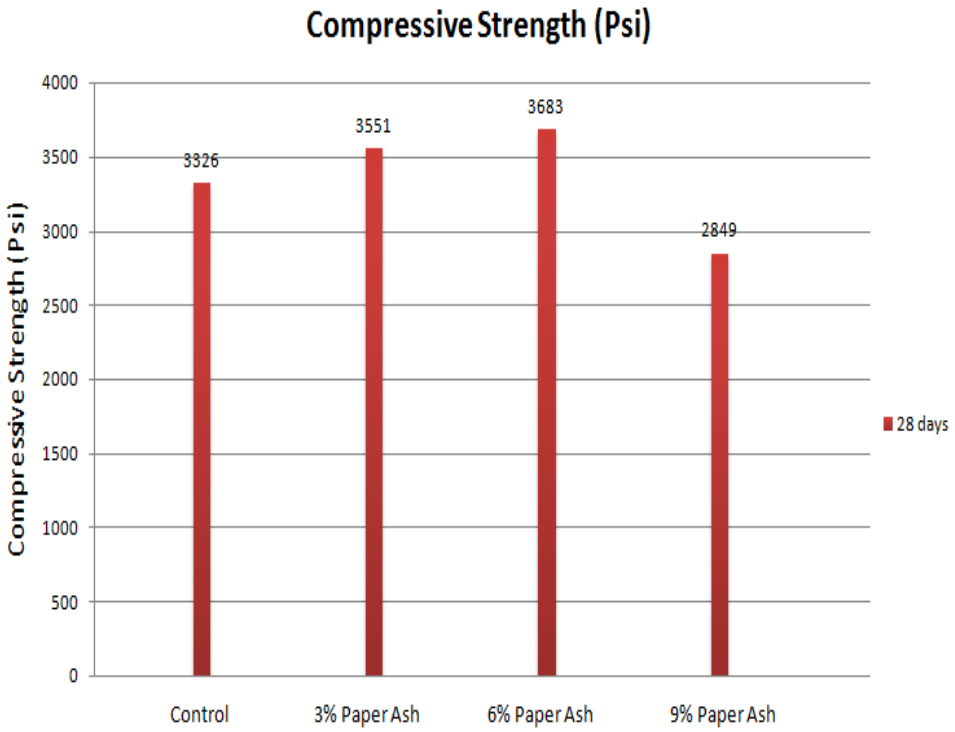

Figure 4.7: Compressive strength at the age of 28 days

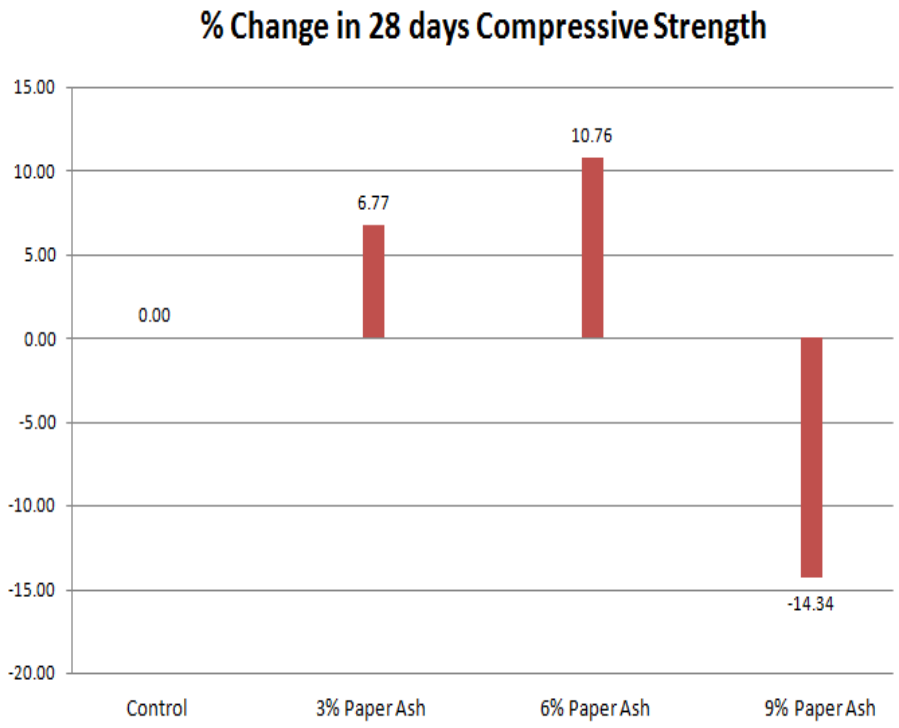

Figure 4.8: Percent change in compressive strength at the age of 28 days

4.3.2Splitting Tensile Strength of Concrete:

The results taken from the four different samples of concrete cylinders casted and tested for 28 days splitting tensile strength are presented in fig 4.9, 4.10. It was observed during testing the specimen that the splitting tensile strength at the age of 28 days enhanced upto 3.64% and 6.36% by incorporating 3% and 6% paper ash respectively as a substitution of OPC to the mix. When the amount of paper ash was further increased to 9% as a substitution of OPC, it resulted in the decrease of split tensile strength by 11.82%. The results are given in table 4.5;

Table 4.5: Splitting tensile strength at the age of 28 days

S#	Sample	Strength (Psi)	W/C Ratio	Increase/ Decrease (%)
1	Control sample	365	0.45	Standard (0%)
2	3% Paper Ash	378	0.45	3.64
3	6% Paper Ash	388	0.45	6.36
4	9% Paper Ash	322	0.45	-11.82

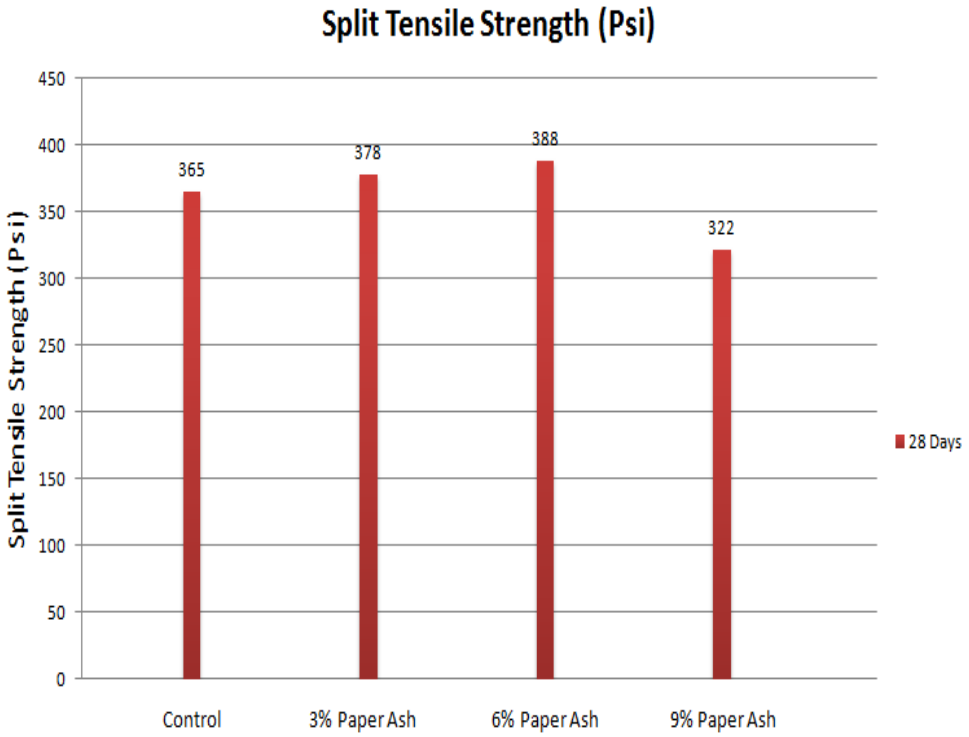

Figure 4.9: Splitting tensile strength at the age of 28 days

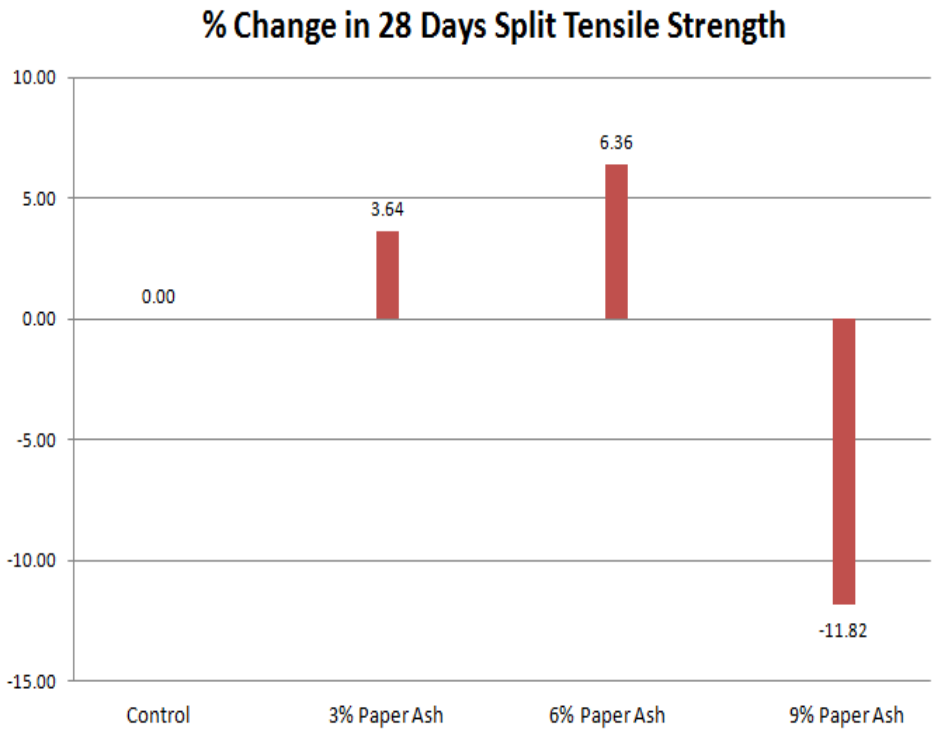

Figure 4.10: Percent change in split tensile strength of 28 days

4.3.3Flexural Strength of Concrete:

The results obtained from the four different samples of concrete beams casted and then tested at 28 days for flexural strength are presented in fig 4.11, 4.12. It was observed during testing the specimen that the flexural strength at28 days increased upto 4.82% and 7.63% by incorporating 3% and 6% paper ash respectively as a substitution of OPC to the concrete mix. When the amount of paper ash was further increased to 9% as a substitution of OPC, it resulted in the decrease of flexural strength by 12.05%. The results are given in table 4.6;

Table 4.6: Flexural strength at the age of 28 days

S#	Sample	Strength (Psi)	W/C Ratio	Increase/ Decrease (%)
1	Control sample	700	0.45	Standard (0%)
2	3% Paper Ash	733	0.45	4.82
3	6% Paper Ash	753	0.45	7.63
4	9% Paper Ash	615	0.45	-12.05

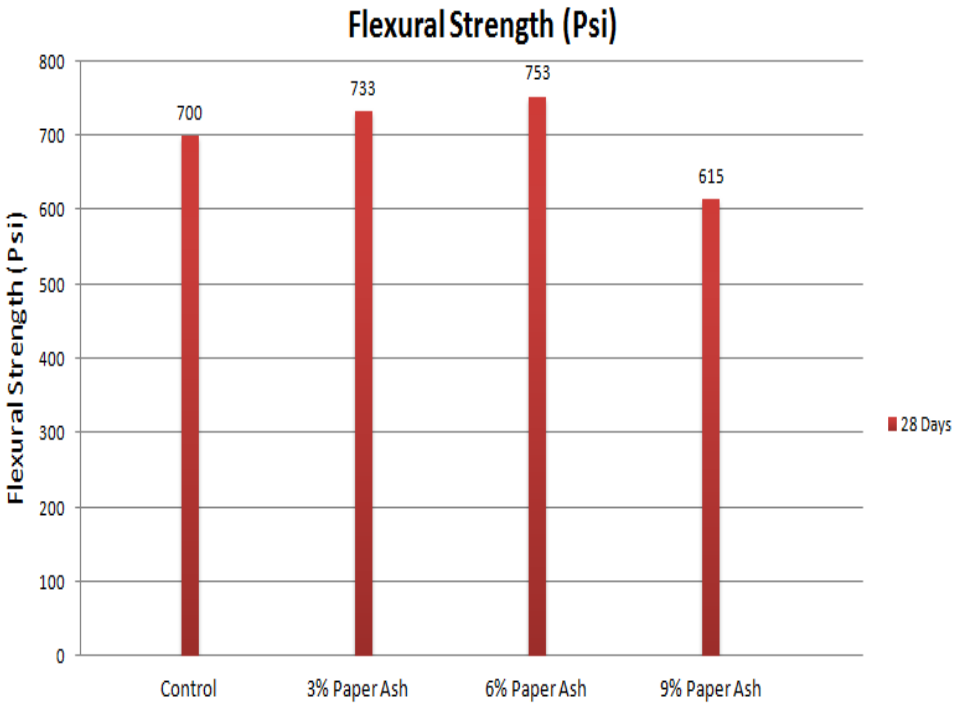

Figure 4.11: Flexural strength at 28 days

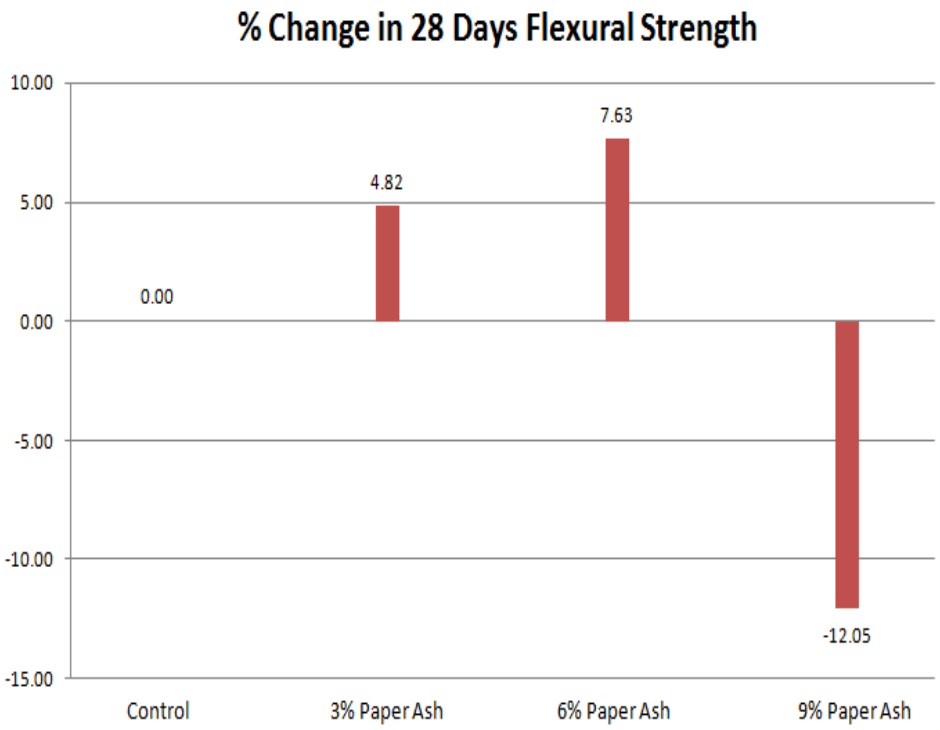

Figure 4.12: Percent change in flexural strength at 28 days

4.4 Results of Slump Tests:

Slump tests are performed during the casting of concrete in laboratory. The results of which are given in following table 4.7

Table 4.7: Slump values

S#	Sample	Slump Value (Inches)
1	Control Sample	Collapse slump (No value)
2	3% Paper Ash	2.50
3	6% Paper Ash	1.50
4	9% Paper Ash	1.25

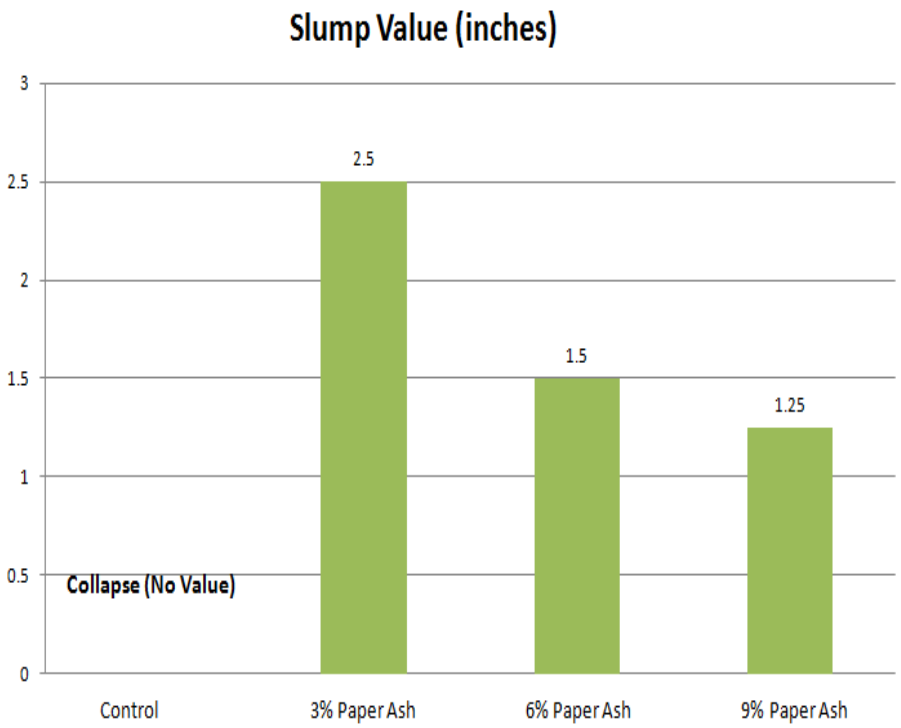

Figure 4.13: Slump values

CHAPTER-5

CONCLUSIONS AND RECOMMENDATIONS

The above research work appeals the following conclusions and recommendations.

5.1 CONCLUSIONS:

Following conclusion can be made from the research work on concrete incorporating paper ash.

- The slump value of concrete sample reduces as the amount of paper ash increased. The control sample having no paper ash has collapse slump because of plasticizer, while the slump value of concrete mix is 2.50 inches for 3% paper ash, 1.50 inches for 6% paper ash and 1.25 inches for 9% paper ash as a substitution of cement.
- The paper ash is very much water absorbent material. As the amount of paper ash increase, it absorbs water in mix and makes the mix very harder, thus increasing the strength.
- Paper ash adds blackish colour to the mix also.
- All the three strengths (compressive strength, split tensile strength, and flexural strength) increased in comparison with control sample upto 6% of replacement of paper ash for both 7 and 28 days strengths.
- The strengths reduced on further replacement of paper ash.
- Maximum increase was observed in compressive strength on 6% of replacement of paper ash for both 7 days and 2

5.2 RECOMMENDATIONS:

The research work investigated the effect of paper ash on concrete. During the research work it was observed that the preparation of the above mentioned material was a tough job. The paper ash was produced by burning the waste papers and then passed through sieve to get particle size of sieve 100 passing and sieve # 200 retained. Keeping in mind the observations during the experimental work, the following key recommendations can be concluded for an efficient research work in future.

- The material should be prepared in construction industry for the ease of making concrete mix.
- The ash collected from other different industries can be efficiently incorporated in concrete by processing it and made it able as per the research work.

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