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An Experimental Investigation of Partial Replacement of Cement by Paper Pulp in Concrete

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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 and 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 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 were the ideal percentages to increase the compressive and flexural strengths of concrete.

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

I. 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, flexural strength, split tensile strength and durability are worked out in this paper.

1.1 Material used:

1.1.1 Cement (PPC):

Portland Pozzolana Cement of brand, Wonder Cement is used. The primary raw materials used for this cement manufacture are limestone ($CaCO_2$) and clay (SiO_2, AI_2O_3, and Fe2O3). It is an eco-friendly cement as the material used in the manufacture are made of natural recycled waste and reduces the carbon monoxide emission from the concrete. Pozzolana consists of silica material which makes it cheap and hence reduces the cost of the cement making it economical to use. Specific gravity of cement is 3.15 and fineness of cement is 3% (by sieve analysis).

1.1.2 Fine Aggregate (Sand):

The fine aggregate (sand) was passing through 150μ to 4.75 mm sieve are used. The grading zone of fine aggregate was found zone II as per Indian Standard specifications.

Table 1.1 Physical Properties of Fine Aggregate

Sr. No.	Property	Average
1	Specific Gravity	2.65
2	Fineness Modulus	2.76
3	Water Absorption	2%
4	Surface Texture	Smooth
5	Particle Shape	Angular

1.1.3 Coarse Aggregate:

The coarse aggregates were available at college site from local quarry. Coarse aggregate are the crushed stone is used for making concrete. As per IS-383:1970, the maximum size of coarse aggregate are used 20 mm.

Table 1.2 Physical Properties of Course Aggregate

Sr. No.	Property	Average
1	Specific gravity	2.70
2	Fineness Modulus	2.54
3	Water Absorption	0.5%
4	Particles Shape	Angular
5	Crushing Value	17.4
6	Impact Value	12.50

1.1.4 Paper Pulp:

Waste paper:- Paper is the main ingredient of papercrete and hence the properties of papercrete depend on the microstructure pf paper used .Due to anisotropic of paper, the quality and strength of its fibers , depending on several factors.

Pulp is a lignocellulosic fibrous material prepared by chemically or mechanically separating cellulose fibers from wood, fiber crops, waste paper, or rags. Mixed with water and other chemical or plant-based additives, pulp is the major raw material used in papermaking and the industrial production of other paper products.

Papercrete is a new composite material using waste paper as a partial replacement of Portland cement. By using the waste paper, papercrete reduces the amount of cement use as well as it makes environment friendly building material. Papercrete is an alternative building material which reduces dead load for the main structure. The basic constituents of papercrete are water and any kind of paper.

Fig.1.4 Paper Pulp Used

Table 1.3 Physical Properties of Paper Pulp

Properties	**Observed Values**
Color	Dark grey
Specific gravity	2.2
Fineness modulus	20000 m^2/kg
Bulk Modulus	240 kg/m^3

Table 1.4 Chemical Properties of Paper Pulp

Properties	**Observed value**
SiO_2	6.32%
Al_2O_3	1.42%
Fe_2O_3	0.76%
MgO	0.8%
CaO	53.14%
Na_2O	<0.01%
K_2O	<0.01%
S	1.0%
Loss of ignition (S)	38.80%

II. METHODOLOGY:

Cubes, cylinders and beams are prepared to obtain the compressive strength, split tensile strength and flexural strength respectively. The specimens are casted and cured for 7, 14 and 28 days and cured specimens are tested and the results are obtained.

- The compressive strength was conducted by the cube specimen of size 150 X 150 X 150 mm and the compressive strength was computed by the standard stress formula P/A, where P is the ultimate load in KN and A is the area in m^2.
- The split tensile strength was conducted by the cylinder specimen 150 X 300 mm and computed by using the expression $ft = 2P/\pi LD$, where P is the ultimate load in KN, L is the depth of the cylinder in m and D is the diameter of the cylinder in m.
- The flexural strength was conducted by the beam of size 500 X 150 X 150 mm and computed by using the expression PL / bd^2, where P is the ultimate load in KN, L is the span between the rollers (40cm), b is the breadth of the beam in meter and d is the depth of the beam in meter.
- The durability test had done by using the cube specimen size 150 X 150 X 150 mm and immersed in sulphuric acid for 56 days and after that the compressive strength of these specimens are determine and also noted weight of these specimens. The percentage in loss of compressive strength and weights has found out and compare with conventional concrete cube specimens.
- The water absorption test had done by using the cube specimen size 150 X 150 X 150 mm and immersed in water for 24 hours. The weight of sample before immersion is W1 and after immersion of 24 hours is W2 is observed and water absorption is computed by applying formula (W2 – W1)/(W1)x100

III. RESULTS AND DISCUSSION:

Grade of Concrete	M20	M25	M30
Mix Proportions	1: 1.52: 3.14	1: 1.45: 3.0	1: 1.34: 2.77
Cement	383 kg/m^3	399 kg/m^3	425.77 kg/m^3
Water	191.6 lit/m^3	191.6 lit/m^3	191.6 lit/m^3
Fine aggregate	583.13 kg/m^3	578.68 kg/m^3	571.25 kg/m^3
Coarse aggregate	1206.26 kg/m^3	1197.08 kg/m^3	1181.70 kg/m^3
Water Cement ratio	0.50	0.48	0.45

Result of testing materials: From the above methodology the result of the testing material as shown in below:

3.1 Fresh Concrete:

3.1.1 Initial and Final setting time test:

Table 3.1 Initial and Final setting time test

S. No	Setting Time (minutes)		Depth of penetration (mm)
	Initial	Final	
1.	37 minutes	10 hrs.	5 mm

Result:- 1. The initial setting time of the cement sample is found to be 37 minutes

2. The final setting time of the cement sample is found to be 10 hrs

3.1.2 Consistency test:

Table 3.2 Consistency results of cement

Weight of Cement (gm)	Quantity of Water (gm)	Penetration (mm)	% of Water (P)
400	120	15	0.30
400	132	8	0.33
400	144	6	0.36

Result: - The consistency of cement is 36%

3.1.3 Workability test by Slump Cone apparatus:

Table 3.3 Slump Value (mm)

Different Mix	M20 Grade	M25 Grade	M30 Grade
	w/c ratio 0.50	w/c ratio 0.48	w/c ratio 0.45
M-0 PP	95	91	88
M-5 PP	93	88	86
M-10 PP	90	86	81
M-15 PP	84	80	75
M-20 PP	79	76	70

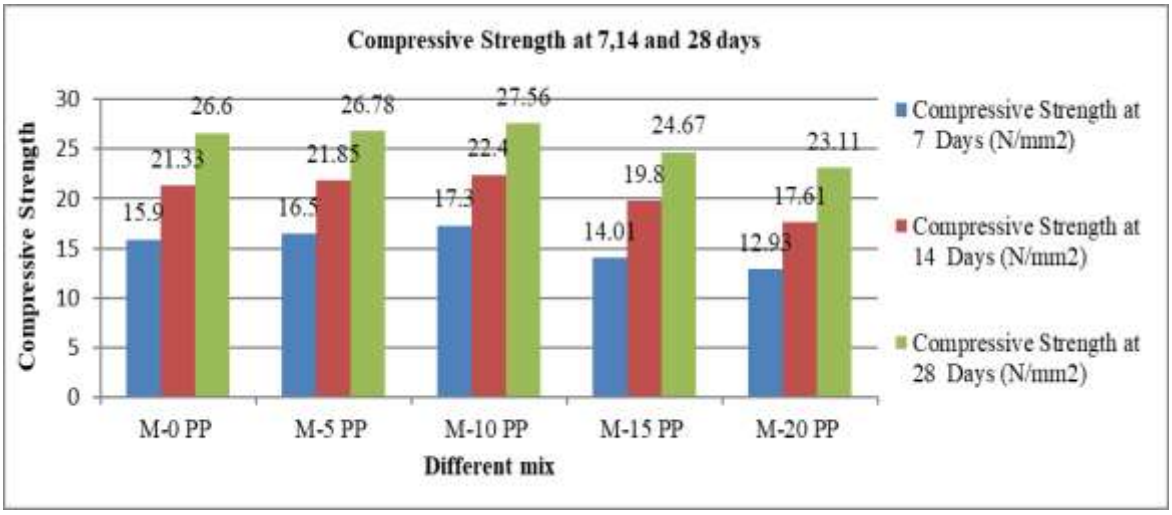
3.2 Hardened Concrete:

Table 3.4 Composition and Notations

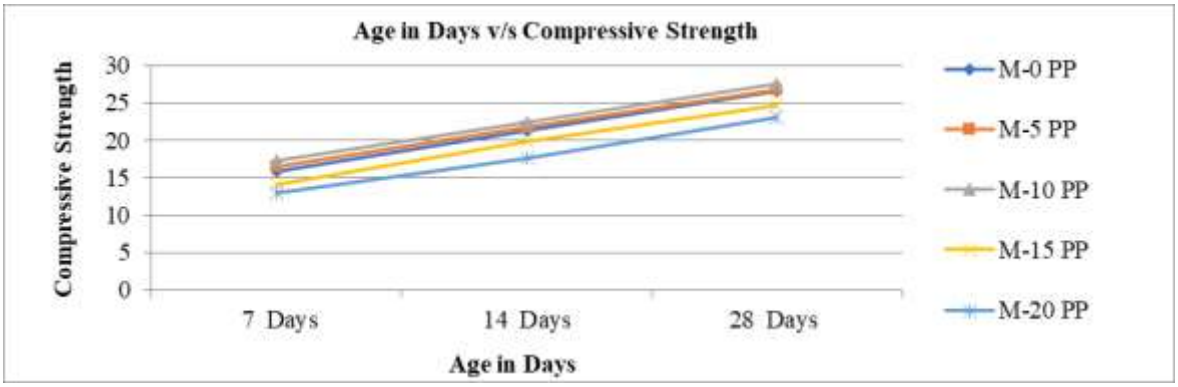
Sr. No.	Composition	Notations
Mix-01	No replacement	M-0 PP
Mix-02	Replacement 5% Paper Pulp	M-5 PP
Mix-03	Replacement 10% Paper Pulp	M-10 PP
Mix-04	Replacement 15% Paper Pulp	M-15 PP
Mix-05	Replacement 20% Paper Pulp	M-20 PP

3.2.1 Compressive Strength Test Result:

- **Compressive Strength Test Results for M20 Grade Concrete-**



Graph 3.1: Compressive Strength in N/mm^2 at various age (Days) For M20 Grade



Graph 3.2: Variation of 7, 14 and 28 days Compressive Strength with variation of % of PP for M20 Grade

Discussions:

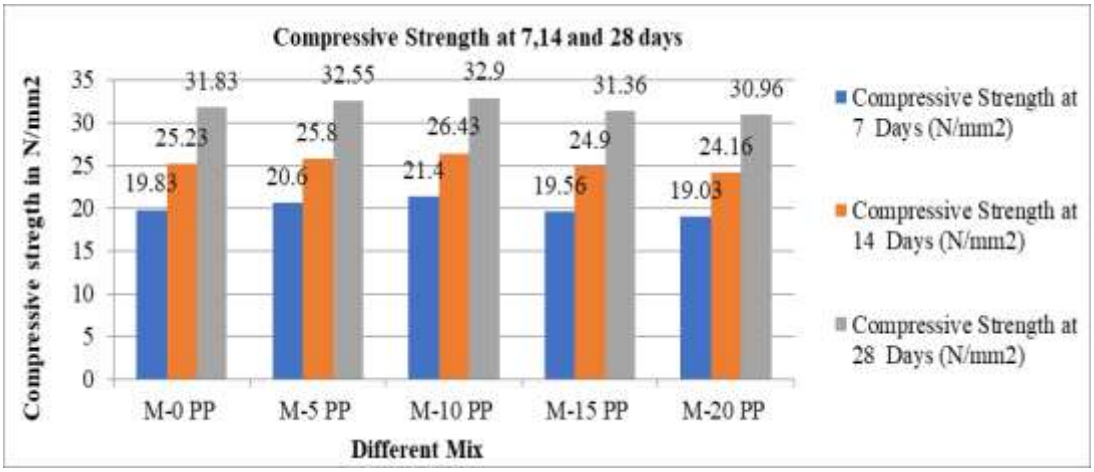
1. **As shown in graph 3.2:** The age in days v/s Compressive strength of concrete cubes with 0% to 20% Paper Pulp replacements are shown in above curves.

- The Compressive strength of concrete cubes in 7, 14 and 28 days of controlled specimen (i.e., M-0 PP) is found as 15.9 N/mm^2, 21.33 N/mm^{2}and 26.60 N/mm^2 respectively.
- For 5% Paper pulp remolded specimen (i.e., M-5 PP) the Compressive strength is increased up to 3.77%, 2.43% and 0.67% respectively.
- For 10% Paper pulp remolded specimen (i.e., M-10 PP) the Compressive strength is increased up to 8.80%, 5.01% and 3.60% respectively.
- For 15% Paper pulp remolded specimen (i.e., M-15 PP), the Compressive strength is decreased up to 11.88%, 7.17%, and 7.25% respectively.
- For 20% Paper Pulp remolded specimen (i.e., M-20 PP)

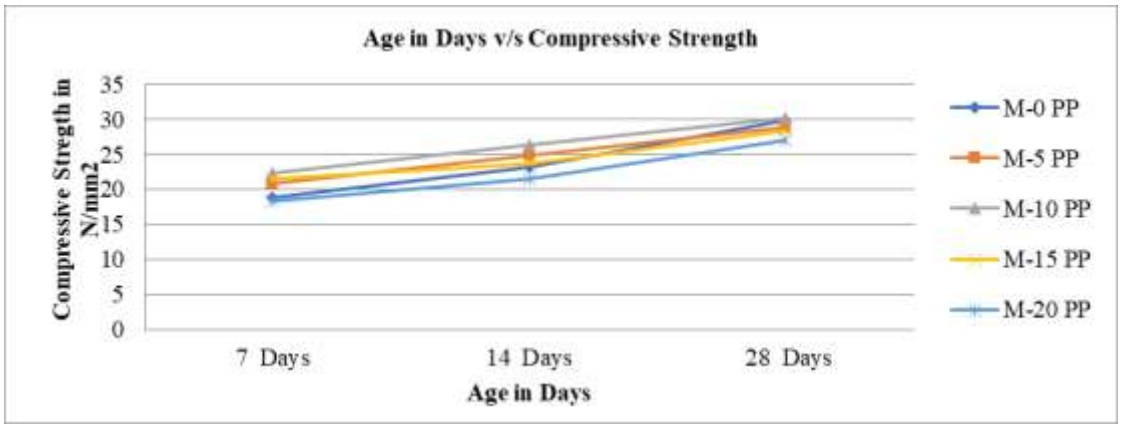
The Compressive strength is decreased up to 18.67%, 17.44% and 13.12% respectively.

- Thus, it is observed from the above discussions that an increase in Compressive strength at 7, 14 and 28 days with replacement of 10% Paper Pulp remolded specimen give 8.80%, 5.01% and 3.60% respectively (i.e., 17.3 N/mm^2, 22.4 N/mm^2 and 27.56 N/mm^2) more Compressive strength as compared with controlled concrete specimen without replacement of Paper Pulp (i.e., 15.9 N/mm^2, 21.33 N/mm^2 and 26.6 N/mm^2).

- **Compressive Strength Test Results for M25 Grade Concrete-**



Graph 3.3: Compressive Strength in N/mm^2 at various age (Days) For M25 Grade

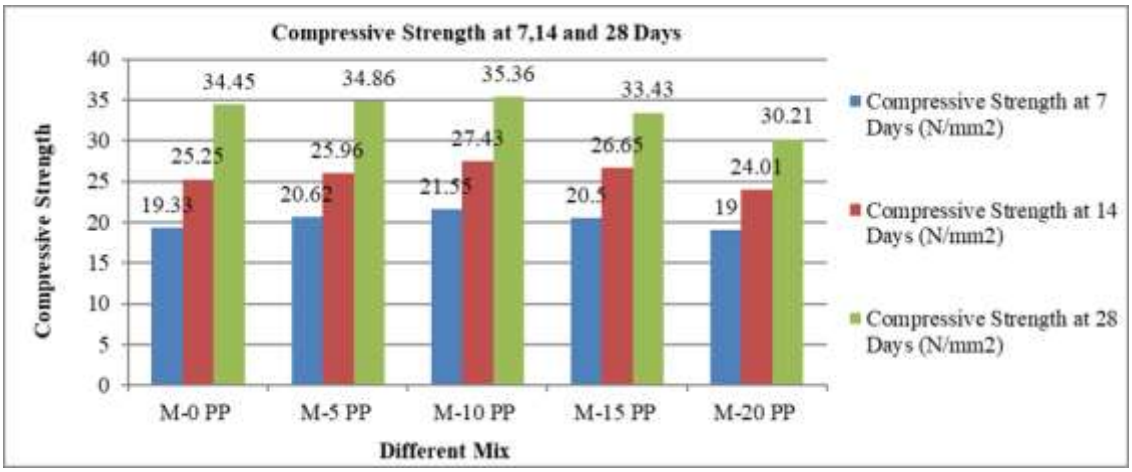


Graph 3.4: Variation of 7, 14 and 28 days Compressive Strength with variation of % of PP for M25 Grade

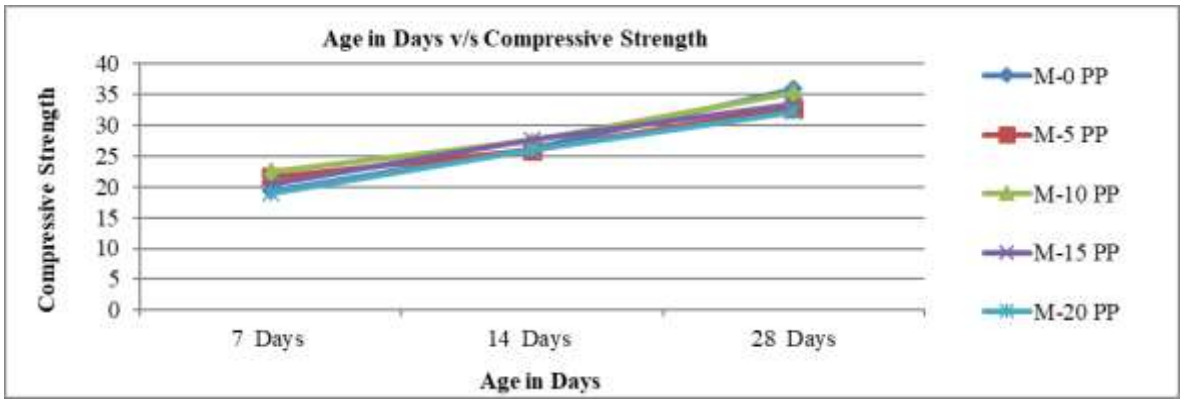
2. **As shown in graph 3.4:** The age in days v/s Compressive strength of concrete cubes with 0% to 20% Paper Pulp replacements are shown in above curves.

- The Compressive strength of concrete cubes in 7, 14 and 28 days of controlled specimen (i.e., M-0 PP) is found as 19.83 N/mm^2, 25.23 N/mm^{2}and 31.83 N/mm^2 respectively.
- For 5% Paper pulp remolded specimen (i.e., M-5 PP) the Compressive strength is increased up to 3.88%, 2.25% and 2.26% respectively.
- For 10% Paper pulp remolded specimen (i.e., M-10 PP) the Compressive strength is increased up to 7.91%, 4.75% and 3.36% respectively.
- For 15% Paper pulp remolded specimen (i.e., M-15 PP), the Compressive strength is decreased up to 1.36%, 1.30%, and 1.47% respective. For 20% Paper Pulp remolded specimen (i.e., M-20 PP), The Compressive strength is decreased up to 4.03%, 4.24% and 2.73% respectively.
- Thus, it is observed from the above discussions that an increase in Compressive strength at 7, 14 and 28 days with replacement of 10% Paper Pulp remolded specimen give 7.91%, 4.75% and 3.36% respectively (i.e., 21.4 N/mm^2, 26.43 N/mm^2 and 32.9 N/mm^2) more Compressive strength as compared with controlled concrete specimen without replacement of Paper Pulp (i.e., 19.83 N/mm^2, 25.23 N/mm^{2}and 31.83 N/mm^2).

- **Compressive Strength Test Results for M30 Grade Concrete-**



Graph 3.5: Compressive Strength in N/mm^2 at various age (Days) For M30 Grade



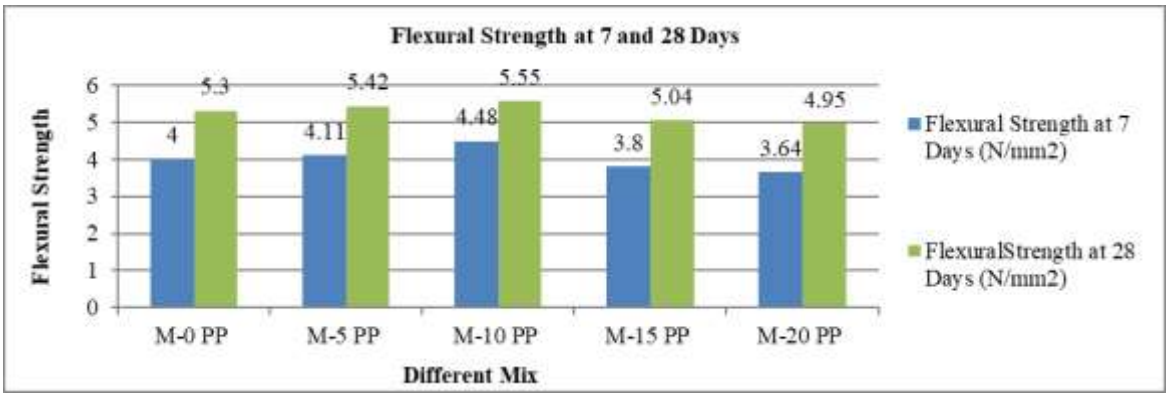
Graph 3.6: Variation of 7, 14 and 28 days Compressive Strength with variation of % of PP for M30 Grade

3. **As shown in graph 3.6:** The age in days v/s Compressive strength of concrete cubes with 0% to 20% Paper Pulp replacements are shown in above curves.

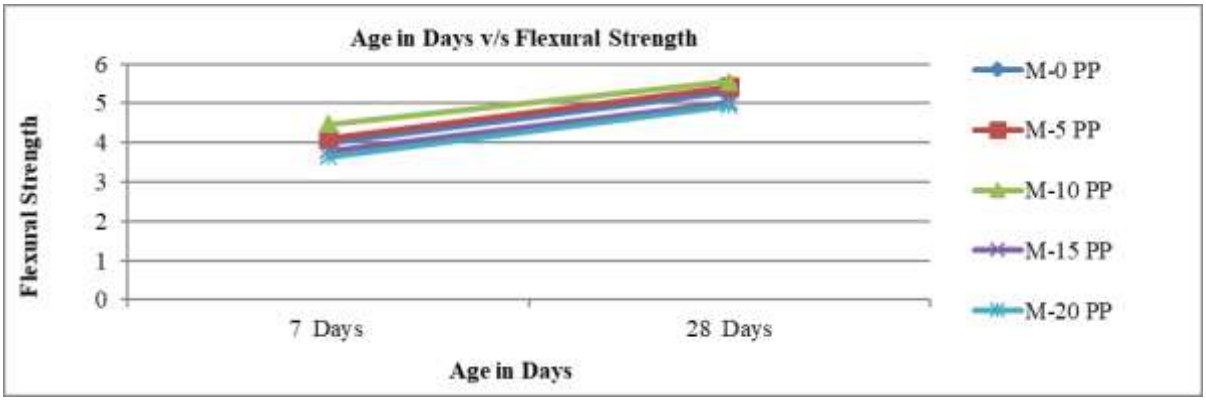
- The Compressive strength of concrete cubes in 7, 14 and 28 days of controlled specimen (i.e., M-0 PP) is found as 19.33 N/mm^2, 25.25 N/mm^{2}and 34.45 N/mm^2 respectively.
- For 5% Paper pulp remolded specimen (i.e., M-5 PP) the Compressive strength is increased up to 6.67%, 2.81% and 1.19% respectively.
- For 10% Paper pulp remolded specimen (i.e., M-10 PP) the Compressive strength is increased up to 11.48%, 8.63% and 2.64% respectively.
- For 15% Paper pulp remolded specimen (i.e., M-15 PP), the Compressive strength is increased up to 6.05%, 5.54% for 7, 14 days and decreased up to 1.47% for 28 days respectively.
- For 20% Paper Pulp remolded specimen (i.e., M-20 PP), The Compressive strength is decreased up to 1.70%, 4.91% and 12.30% respectively.
- Thus, it is observed from the above discussions that an increase in Compressive strength at 7, 14 and 28 days with replacement of 10% Paper Pulp remolded specimen give to 6.67%, 2.81% and 1.19% respectively (i.e., 21.55 N/mm^2, 27.43 N/mm^2 and 35.36 N/mm^2) more Compressive strength as compared with controlled concrete specimen without replacement of Paper Pulp (i.e., 19.33 N/mm^2, 25.25 N/mm^{2}and 34.45 N/mm^2).

3.2.2 Flexural strength Test Result:

- **Flexural Strength Test Results for M20 Grade Concrete-**



Graph 3.7 Flexural Strength in N/mm^2 at various age (Days) for M20 Grade



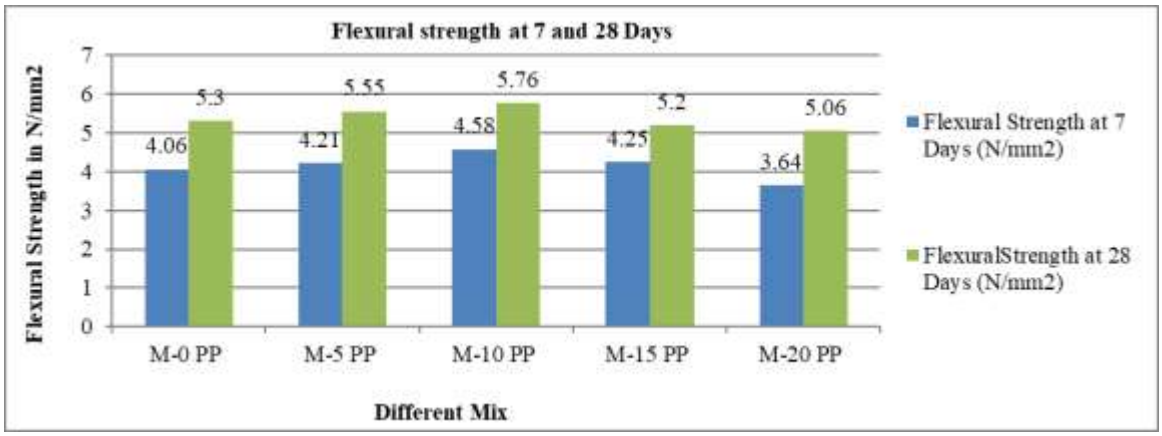
Graph 3.8 Variation of 7 and 28 days Flexural Strength with variation of % of PP for M20 Grade

Discussions:

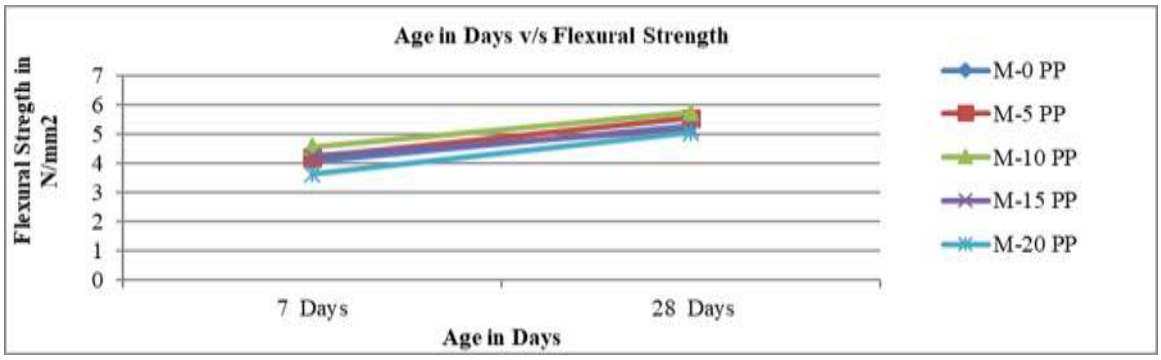
1. **As shown in graph 3.8:** The age in day's v/s Flexural strength of concrete beams with 0% to 20% Paper Pulp (PP) and replacements are shown in above curves.

- The Flexural strength of concrete beams with 7 and 28 days of controlled specimen (M-0 PP) is found as 4 N/mm^2 and 5.3 N/mm^2.
- For 5% Paper pulp remolded specimen (i.e., M-5 PP) the Flexural strength is increased up to 2.75%and 2.26% respectively.
- For 10% Paper pulp remolded specimen (i.e., M-10 PP), the Flexural strength is increased up to 12% and 4.71% respectively.
- For 15% Paper pulp remolded specimen (i.e., M-15 PP), the Flexural strength is decreased up to 5.26%, and 4.90% respectively.
- For 20% Paper pulp remolded specimen (i.e., M-20 PP), the Flexural strength is decreased up to 9%, and 6.6% respectively.
- Thus, it is observed from the above discussions that an increase in Flexural strength at 7 and 28 days with replacement of 10% Paper pulp remolded specimen give 12% and 4.71% (i.e., 4.48 N/mm^{2}and 5.55 N/mm^2) more Flexural strength as compared with controlled concrete specimen without replacement of Paper pulp (i.e., 4 N/mm^{2}and 5.3 N/mm^2).

- **Flexural Strength Test Results for M25 Grade Concrete-**



Graph 3.9 Flexural Strength in N/mm^2 at various age (Days) for M25 Grade



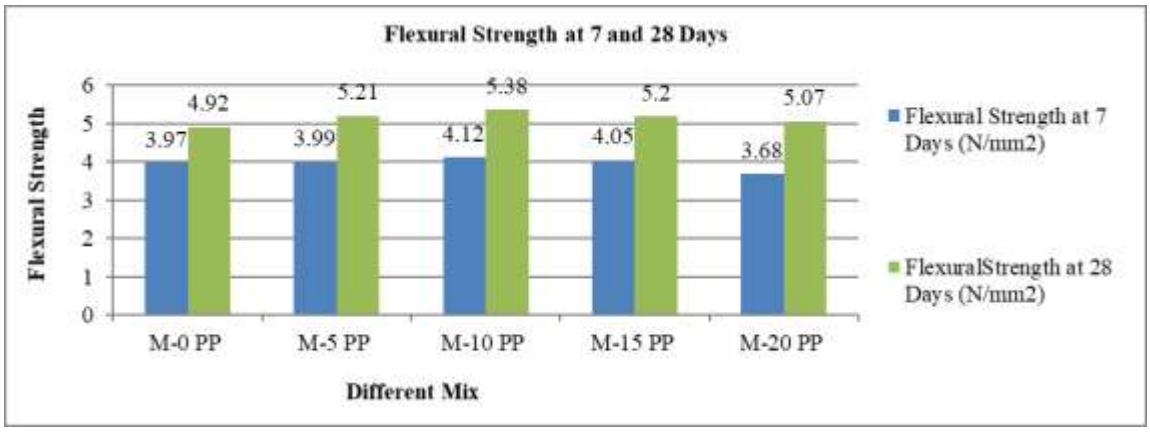
Graph 3.10 Variation of 7 and 28 days Flexural Strength with variation of % of PP for M25 Grade

Discussions:

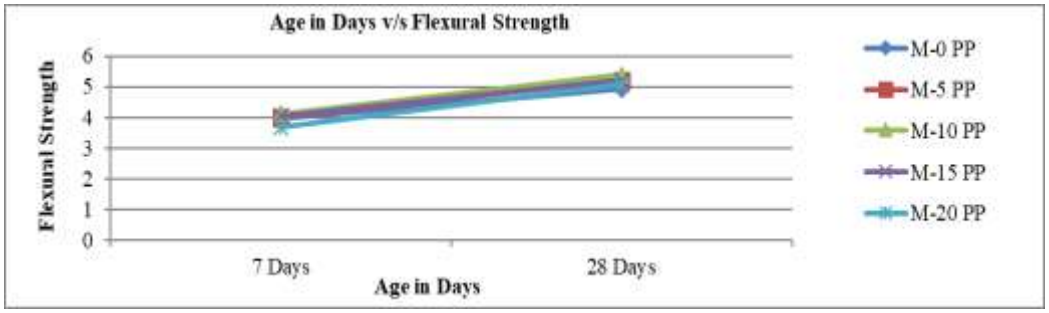
2. **As shown in graph 3.10:** The age in days v/s Flexural strength of concrete beams with 0% to 20% Paper Pulp (PP) and replacements are shown in above curves

- The Flexural strength of concrete beams with 7 and 28 days of controlled specimen (M-0 PP) is found as 4.06 N/mm^2 and 5.3 N/mm^2.
- For 5% Paper pulp remolded specimen (i.e., M-5 PP) the Flexural strength is increased up to 3.69%and 4.71% respectively.
- For 10% Paper pulp remolded specimen (i.e., M-10 PP), the Flexural strength is increased up to 12.80% and 8.67% respectively.
- For 15% Paper pulp remolded specimen (i.e., M-15 PP), the Flexural strength is increased up to 4.67% for 7 days and 1.92% for 28 days respectively.
- For 20% Paper pulp remolded specimen (i.e., M-20 PP), the Flexural strength is decreased up to 10.34%, and 4.52% respectively.
- Thus, it is observed from the above discussions that an increase in Flexural strength at 7 and 28 days with replacement of 10% Paper pulp remolded specimen give 12.80% and 8.67% (i.e., 4.58 N/mm^{2}and 5.76 N/mm^2) more Flexural strength as compared with controlled concrete specimen without replacement of Paper pulp (i.e., 4.06 N/mm^{2}and 5.3 N/mm^2).

- **Flexural Strength Test Results for M30 Grade Concrete-**



Graph 3.11 Flexural Strength in N/mm^2 at various age (Days) for M30 Grade



Graph 3.12 Variation of 7 and 28 days Flexural Strength with variation of % of PP for M30 Grade

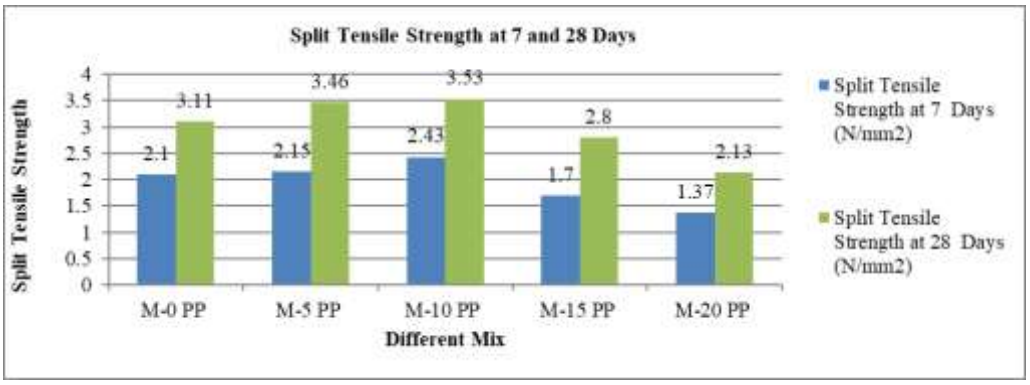
Discussions:

As shown in graph 3.12: The age in days v/s Flexural strength of concrete beams with 0% to 20% Paper Pulp (PP) and replacements are shown in above curves.

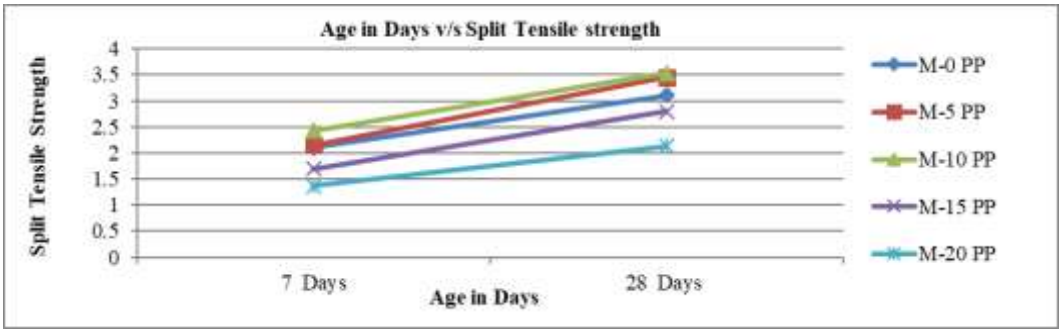
- The Flexural strength of concrete beams with 7 and 28 days of controlled specimen (M-0 PP) is found as 3.97 N/mm^2 and 4.92 N/mm^2.
- For 5% Paper pulp remolded specimen (i.e., M-5 PP) the Flexural strength is increased up to .50%and 5.89% respectively.
- For 10% Paper pulp remolded specimen (i.e., M-10 PP), the Flexural strength is increased up to 3.77% and 9.74% respectively.
- For 15% Paper pulp remolded specimen (i.e., M-15 PP), the Flexural strength is increased up to 2.01%, and 5.69% respectively.
- For 20% Paper pulp remolded specimen (i.e., M-20 PP), the Flexural strength is decreased up to 7.30% for 7 days and increased up to 3.04% for 28 days respectively.
- Thus, it is observed from the above discussions that an increase in Flexural strength at 7 and 28 days with replacement of 10% and 20% Paper pulp remolded specimen give 3.77% and 9.34% for 10% and 2.01% and 5.69% for 20% (i.e., 4.12 N/mm^{2}and 5.38 N/mm^2 for 10% and 4.05 N/mm^{2}and 5.2 N/mm^2 for 20%) more Flexural strength as compared with controlled concrete specimen without replacement of Paper pulp (i.e., 3.97 N/mm^{2}and 4.92 N/mm^2).

3.2.3 Split Tensile Strength Test:

- **Split Tensile Strength Test Results for M20 Grade Concrete-**



Graph 3.13 Split Tensile Strength in N/mm^2 at various age (Days) for M20 Grade



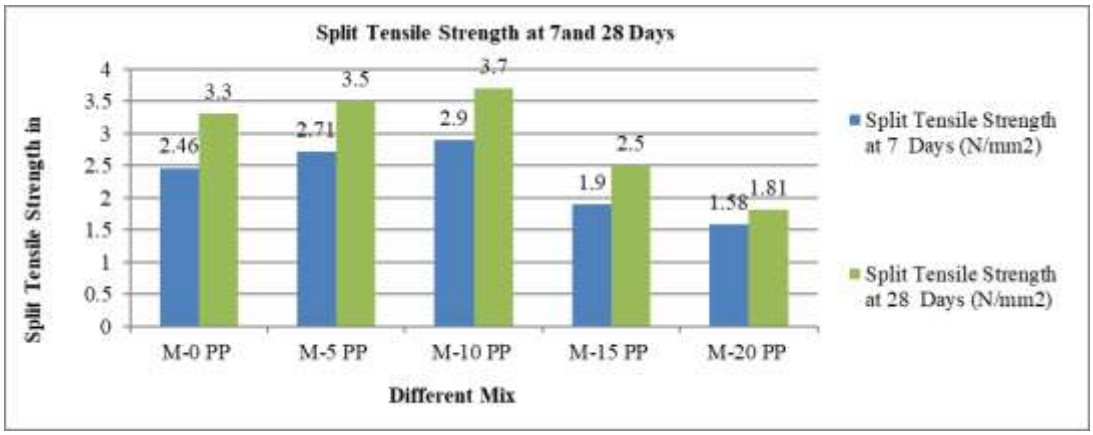
Graph 3.14 Variation of 7 and 28 days Split Tensile Strength with variation of % of PP for M20 Grade

Discussions:

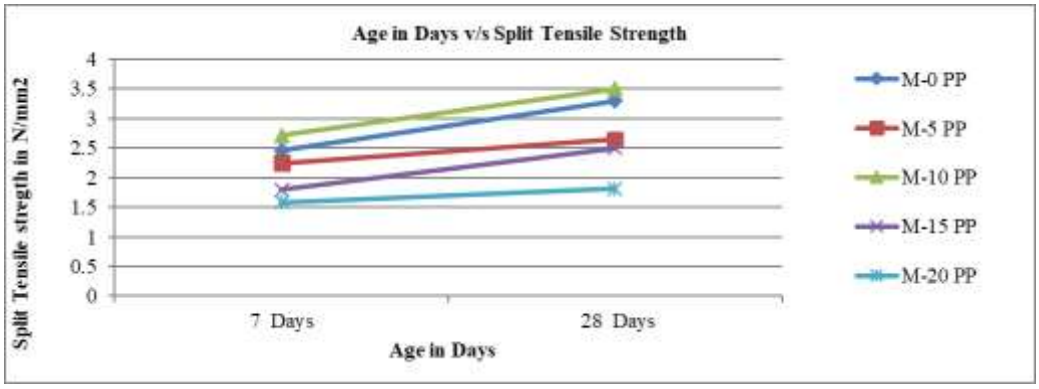
As shown in graph 3.14: The age in days v/s Split tensile strength of concrete cylinders with 0% to 20% Paper Pulp (PP)) replacements are shown in above curves.

- The Split tensile strength of concrete cylinders at 7 and 28 days of controlled specimen (M-0 PP) is found as 2.1 N/mm^2 and 3.11 N/mm^2 respectively.
- For 5% Paper pulp remolded specimen (i.e., M-5 PP), the Split tensile strength is increased up to 2.38% and 11.25% at 7 and 28 days respectively
- For 10% Paper pulp remolded specimen (i.e., M-10 PP), the Split tensile strength is increased up to 15.71% and 13.50% at 7 days and 28 days respectively
- For 15% Paper pulp remolded specimen (i.e., M-15 PP), the Split tensile strength is decreased up to 19.04% and 9.96% at 7 days and 28 days respectively.
- For 20% Paper pulp remolded specimen (i.e., M-20 PP), the Split tensile strength is decreased up to 34.76% and 31.51% at 7 days and 28 days respectively.
- Thus, it is observed that the Split tensile strength is increases up to 10% paper pulp replacement.

- **Split Tensile Strength Test Results for M25 Grade Concrete-**



Graph 3.15 Split Tensile Strength in N/mm^2 at various age (Days) for M25 Grade



Graph 3.16 Variation of 7 and 28 days Split Tensile Strength with variation of % of PP for M25 Grade

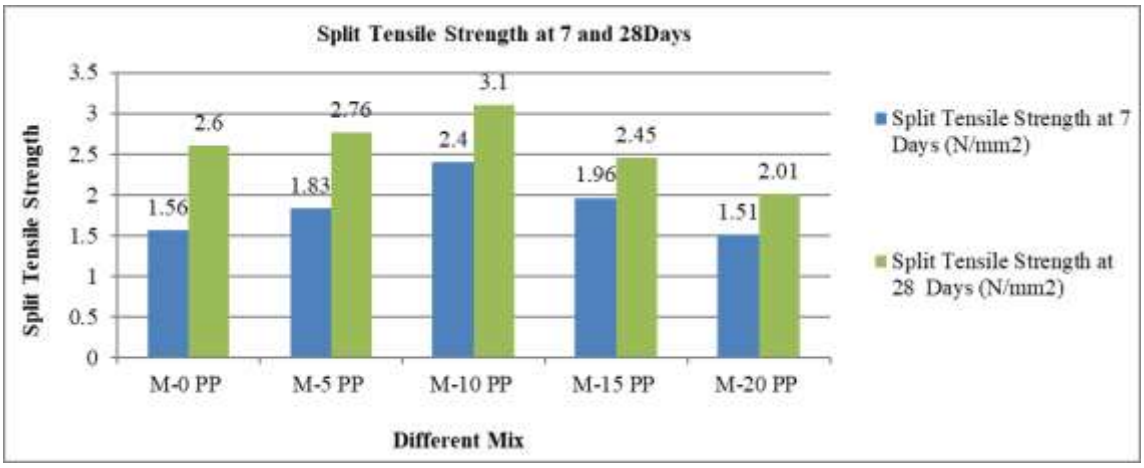
Discussions:

As shown in graph 3.16: The age in days v/s Split tensile strength of concrete cylinders with 0% to 20% Paper Pulp (PP)) replacements are shown in above curves.

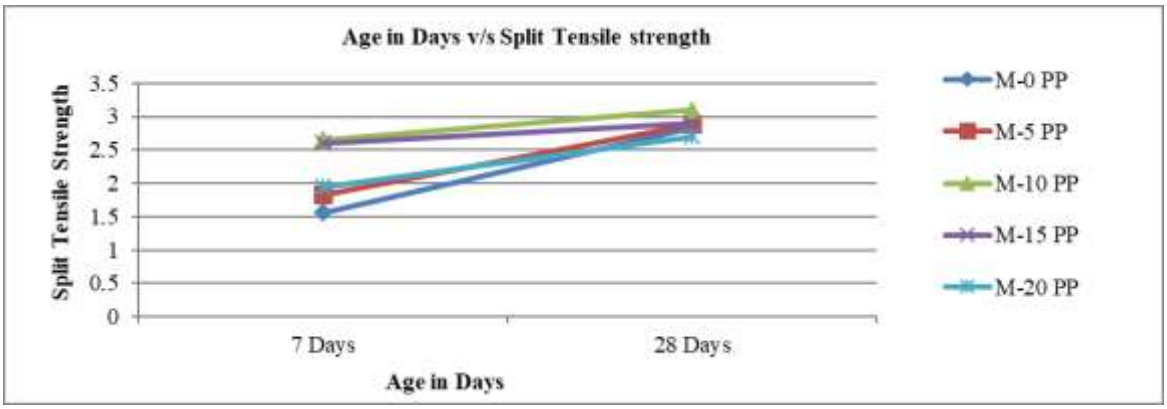
- The Split tensile strength of concrete cylinders at 7 and 28 days of controlled specimen (M-0 PP) is found as 2.46N/mm^2 and 3.3N/mm^2 respectively.
- For 5% Paper pulp remolded specimen (i.e., M-5 PP), the Split tensile strength is increased up to 10.16% and 6.06% at 7 and 28 days respectively
- For 10% Paper pulp remolded specimen (i.e., M-10 PP), the Split tensile strength is increased up to 17.88% and 12.12% at 7 days and 28 days respectively
- For 15% Paper pulp remolded specimen (i.e., M-15 PP), the Split tensile strength is decreased up to 22.76% and 24.24% at 7 days and 28 days respectively.
- For 20% Paper pulp remolded specimen (i.e., M-20 PP), the Split tensile strength is decreased up to 35.77% and 45.15% at 7 days and 28 days respectively.

Thus, it is observed that the Split tensile strength is increases up to 10% paper pulp replacement.

- **Split Tensile Strength Test Results for M30 Grade Concrete-**



Graph 3.17 Split Tensile Strength in N/mm^2 at various age (Days) for M30 Grade



Graph 3.18 Variation of 7 and 28 days Split Tensile Strength with variation of % of PP for M30 Grade

Discussions:

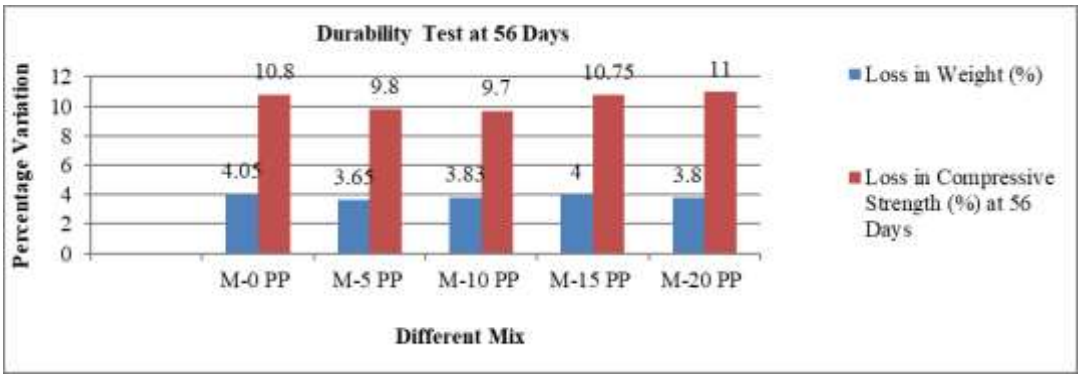
As shown in graph 3.18: The age in days v/s Split tensile strength of concrete cylinders with 0% to 20% Paper Pulp (PP)) replacements are shown in above curves.

- The Split tensile strength of concrete cylinders at 7 and 28 days of controlled specimen (M-0 PP) is found as 1.56 N/mm^2 and 2.6N/mm^2 respectively.
- For 5% Paper pulp remolded specimen (i.e., M-5 PP), the Split tensile strength is increased up to 14.75% and 6.15% at 7 and 28 days respectively
- For 10% Paper pulp remolded specimen (i.e., M-10 PP), the Split tensile strength is increased up to 53.84% and 19.23% at 7 days and 28 days respectively
- For 15% Paper pulp remolded specimen (i.e., M-15 PP), the Split tensile strength is increased up to 25.64% for 7 days and decreased 5.76% for 28 days respectively.
- For 20% Paper pulp remolded specimen (i.e., M-20 PP), the Split tensile strength is decreased up to 3.20% and 22.69% at 7 days and 28 days respectively.
- Thus, it is observed that the Split tensile strength is increases up to 10% paper pulp replacement.

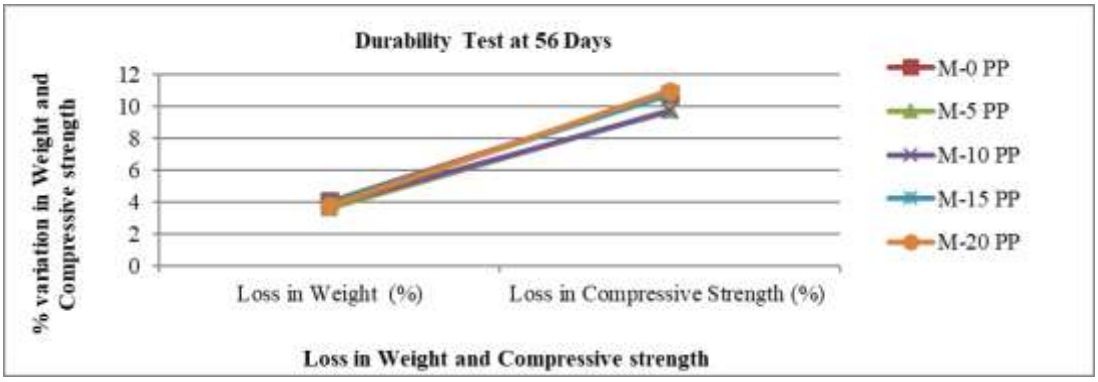
3.2.4 Durability Test Results:

This test was carried out on cube samples of dimensions 150* 150 * 150 mm. These test specimens were cured and tested for 28-days and tested in compressive testing machine.

- **Durability Test results for M20 Grade Concrete-**



Graph 3.19 Durability Test results of Concrete Cube at 56 days for M20 Grade



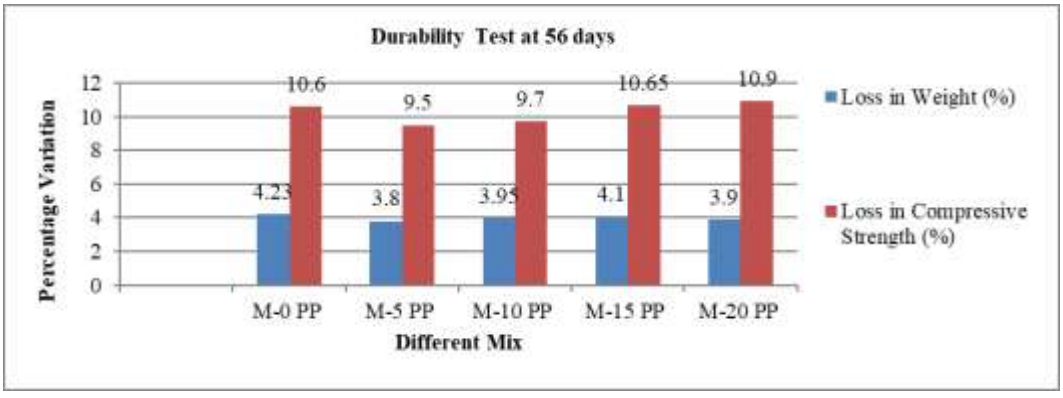
Graph 3.20 Variation of 56 days % loss in weight and compressive strength with variation of % of PP for M20 Grade

Discussions:

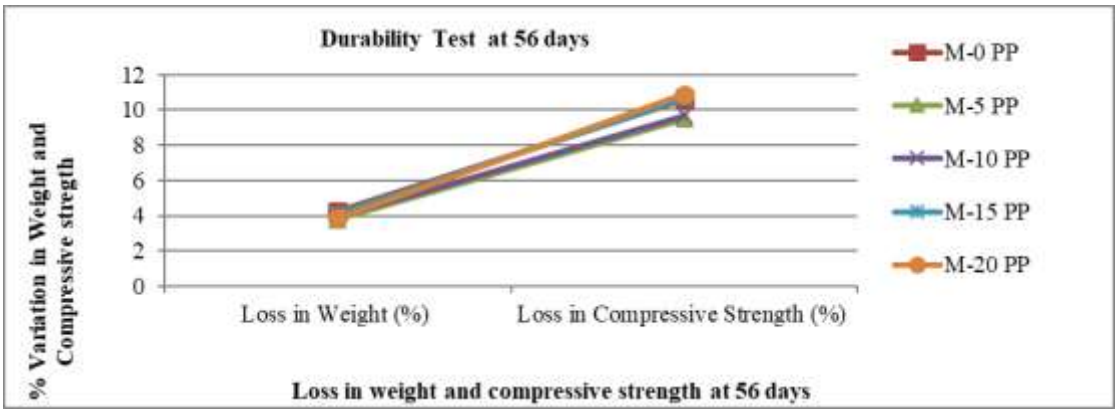
As shown in graph 3.19: The action of acids on concrete is the change of calcium compounds into calcium salts of the attacking acid. These reactions destroy the concrete structure. The percentage loss in compressive strength at 56 days was found to be 10.80% without replacement of paper pulp and replaced with paper pulp were found to be 9.8%, 9.7%, 10.75% and 11% respectively. Thus the strength of concrete cube found to be with paper pulp replaced specimen is greater than conventional concrete specimen. The percentage loss in weight of concrete cube at 56 days was found to be 4.05% without replacement and 3.65%, 3.83%, 4% and 3.8% were found to be with paper pulp replaced concrete specimen. Thus replacement of paper pulp concrete specimen are found to have less affected from weathering agencies.

Thus replacement of paper pulp concrete specimen are found to have increased the durability against acid attack and the optimum percentage of replacement with PP are 5% and 10%.

- **Durability Test results for M25 Grade Concrete-**

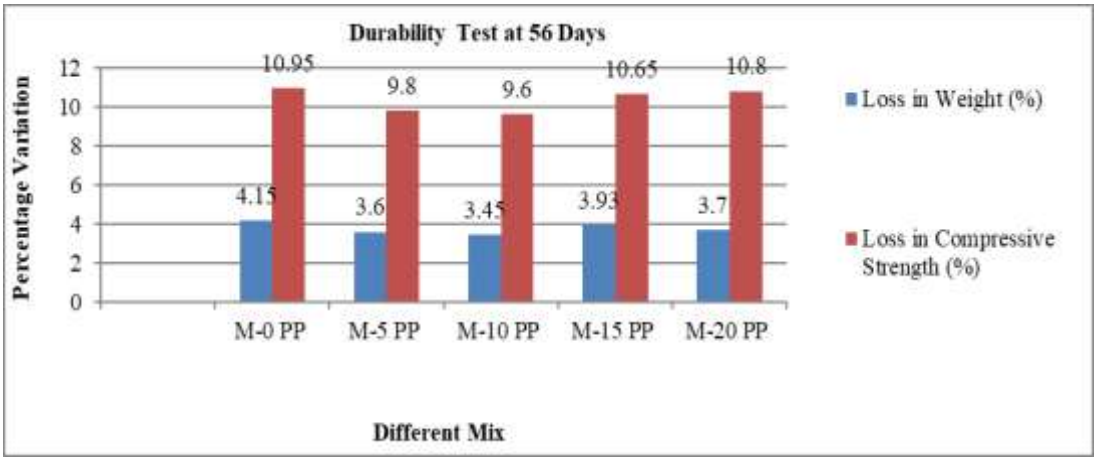


Graph 3.21 Durability Test results of Concrete Cube at 56 days for M25 Grade

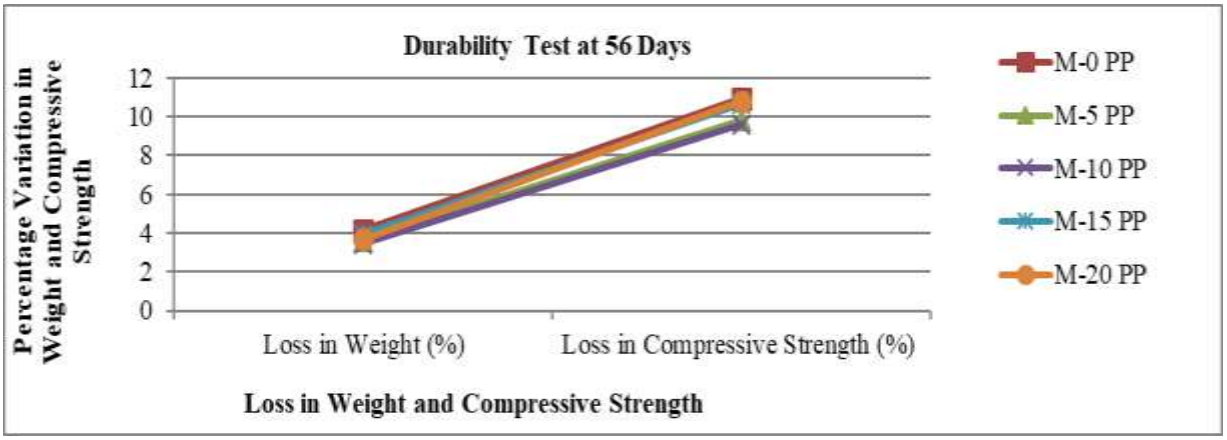


Graph 3.22 Variation of 56 days % loss in weight and compressive strength with variation of % of PP for M25 Grade

- **Durability Test results for M30 Grade Concrete-**

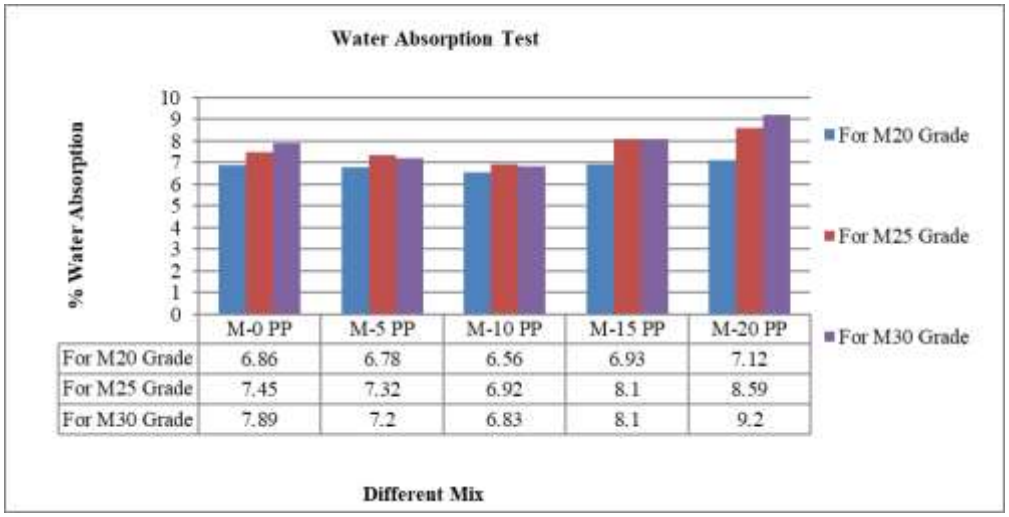


Graph 3.23 Durability Test results of Concrete Cube at 56 days for M25 Grade



Graph 3.24 Variation of 56 days % loss in weight and compressive strength with variation of % of PP for M30 Grade

3.2.5 Water Absorption Test Results-



	M-0 PP	M-5 PP	M-10 PP	M-15 PP	M-20 PP
For M20 Grade	6.86	6.78	6.56	6.93	7.12
For M25 Grade	7.45	7.32	6.92	8.1	8.59
For M30 Grade	7.89	7.2	6.83	8.1	9.2

Graph 3.25 Water Absorption Test results on Concrete Cube for M20, M25 and M30 Grade

Discussions:

As shown in graph 3.21 : The percentage of water absorption for conventional concrete (M-0 PP) is 6.86% and percentage of water absorption for concrete with paper pulp i.e., 5%, 10%, 15%, 20% (M-5,M-10, M-15, M-20) are 6.78%, 6.56%, 6.93% are 7.12% respectively. The percentage of water absorption is minimum for concrete with 10% paper pulp i.e., 6.56% and it is 0.30% less than conventional concrete.

IV. CONCLUSION:

The Compressive strength, Flexural strength, Split tensile strength ,Durability test and water absorption test of concrete mixes made with and without paper pulp has been determined at 7, 14 and 28 days of curing. The strength gained or loss has been determined of paper pulp added concrete with 0%, 5%, 10% & 15% for M20, M25 and M30 grade as partial replacement of cement in controlled concrete. From the results, it is concluded that the paper pulp are superior replacement of cement up to 10% .Paper pulp has high calcium oxide (53%) and silicon oxide (6%) content. The cement in concrete releases hydroxide throughout the hydration process. The silicon oxide from paper pulp reacts with the hydroxide to make further binder material. It is observed that the water absorption changed into increased with the increasing of waste paper content of the mixes. High quantity of water absorption is because of the presence of cellulose substances that effortlessly absorbs water and retains it for long time. Waste paper includes significant quantity of alumina-siliceous, cloth that is mixed with calcium, main to the development in its strength. The development of this energy is predominantly inferable to the hydraulic, and pozzolanic interest of waste paper is activated via, the alkalis and to a point $Ca(OH)_2$ that is launched from the hydration procedure. Compressive strength outcomes for all mixes are indicated for every age (7, 14, and 28 days). The equal trend became seen for splitting tensile strength and flexural strength that is due to loss in cohesion and also, the binding of calcium- hydrate - silicate (C-S-H) gel on cellulosic cloth is extraordinarily poor. Besides adding waste, paper to the concrete blend will maintain extent inside the specimens and any expansion will weaken the concrete. Compressive strength, splitting, tensile strength and flexural strength for mixes decrease with increasing of amount of wastepaper. While the mixture with, (5% & 10%) indicate strength higher to that of reference mix. When activity all the tests and analyzing their result, the subsequent conclusions are derived:

- The percentage increase in Compressive strength at 7,14 and 28 days with replacement of 10% Paper Pulp remolded specimen give 8.80%, 5.01% and 3.60% for M20, 7.91%, 4.75% and 3.36% for M25 grade and 11.48%, 8.63% and 2.64% for M30 grade more Compressive strength as compared with controlled concrete specimen without replacement of Paper Pulp.
- The percentage increase in Flexural strength at 7 and 28 days with replacement of 10% Paper pulp remolded specimen give 12% and 4.71% for M20 grade, 12.80% and 8.67% for M25 grade and 3.77% and 9.74% for M30 grade more Flexural strength as compared with controlled concrete specimen without replacement of Paper pulp.
- The percentage increase in Split Tensile Strength at 7 and 28 days with replacement of 10% Paper pulp remolded specimen give 15.71% and 13.50% for M20 grade, 17.88% and 12.12% for M25 grade and 53.84% and 19.23% for M30 grade more Flexural strength as compared with controlled concrete specimen without replacement of Paper pulp.
- Replacement of paper pulp concrete specimen are found to have increased the durability against acid attack and the optimum percentage of replacement with PP at 10% is 9.7% for M20 grade , 9.7% for M25 grade and 9.6% for M30 grade of concrete respectively.
- The percentage of water absorption is minimum for concrete with 10% paper pulp and it 0.3% less for M20 grade, 0.53% less for M25 grade and 1.06% less for M30 grade of concrete respectively.
- The workability of paper pulp concrete also increases up to 10% replacement of cement as compared to controlled concrete.

- From the results, it is concluded that the Paper pulp is superior replacement of Cement up to 10%.

Future Scope: Recommendations for Future Research-

From this research, there are few recommendations to develop, to extend and to explore the usage of silica fume and stone dust in concrete:

- Define the effect of Paper pulp on concrete with the replacement of mixture of coarse and fine aggregate by volume method.
- Replacement of cement with Paper pulp in different water cement ratio and grade of concrete.
- Selected few samples of concrete with different percentage of Paper pulp and conclude the most suitable percentage of usage to achieve the optimum compressive strength.
- Study on effect of concrete with and without replacement of Paper pulp and also compare their cost.

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