International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 02 | Feb-2018 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL INVESTIGATION ON CONCRETE USING WASTE PAPER

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Abstract - *India is facing a serious challenge in disposing of waste in the many landfills throughout the country that are near or at capacity. The landfill situation is resulting in high disposal costs and potential environmental problems. If the current situation continues with waste production is grow by 5% each year, landfills would be at full capacity by 2020. This paper reports on the results of an experimental investigation for concrete using wastepaper as additional materials in concrete mixes to be used in housing projects, for which it must be assured that the waste paper concrete has the proper mechanical strength. Concrete mixes containing various contents of the paper was prepared and basic strength characteristics such as compressive strength, splitting tensile were determined and compared with a control mix. The concrete mixes containing of the waste material, such as conventional concrete, 5%, 10%, 15% as an additional materials to concrete were prepared with ratios of 1:1.5:3 by weight of cement, sand, and coarse aggregate respectively. The maximum size of coarse aggregate was 20mm. In this work, the strength of concrete was increased by adding the paper pulp into the concrete upto 10%. The test results indicate that additional use of waste paper pulp above 10% in concrete has reduced the strength of concrete.*

Key Words: Waste paper, Paper pulp, Compressive strength, Split tensile strength, Flexural strength.

1. INTRODUCTION

In the developing countries, the disposal of waste paper is a major problem. According to a research, more than 400 million tons of papers are produced worldwide every year. It is estimated that by 2020, paper mills will be producing 450 million tons of paper and paperboard each year. We obviously need this product and a reduction of use is not in the prospect. Pulp and paper is the 3rd largest industrial polluter of air, water and soil. In recent year, paper and paperboard constitute a greater portion of many countries municipal solid waste generation. According to the Environment Protection Agency (EPA), the Unites States recycles about 50% of discarded paper annually. This means that about 60% or 50 million tons of paper ends up in landfill sites while some are incinerated. Waste paper reusing has not been able to match waste paper generation. Since the large demand has been placed for the construction industry, especially in the last decade due to increase in pollution which cause a chronic shortage of building resources, the civil engineers have been challenged to convert the industrial waste to useful building and construction materials. One exclusive recycle opportunity is using waste paper as a construction material. In recent years, there has been a renaissance of interest in traditional building material, particularly those made from renewable or recycled materials "papercrete" is one of such materials attracting public interest. Papercrete gets the name from fact that most formulas purpose of a mixture of water and the cement with cellulose fiber.

2. MATERIALS USED

2.1 Cement

Cement is one of the binding material in this project. Cement is the important binding material in today's construction world. 53 grade Ordinary Portland Cement (OPC) is used as per IS: 8112-1989 . Table 1 gives the properties of cement used.

2.2 Fine Aggregate

Fine aggregate i.e., Sand obtained locally from nearest river passing through 4.75 mm IS sieve having fineness modulus (F.M)-2.61 and confirming to zone-III as per IS: 383-1970 [17] and its physical properties are enlisted in Table 2.

2.3 Coarse Aggregate

Coarse aggregate include natural aggregates. Locally available crushed stone of 20 mm down sizes confirming to IS: 383 have been used as coarse aggregate. The physical properties of coarse aggregate like specific gravity, fineness modulus etc. were tested in accordance with IS 2386. Table 3 gives the properties of coarse aggregates.

2.4 Paper

Paper is a material produced by the cellulose pulp derived from wood, rags or glasses and drying them into flexible sheets. This is a most available material with many purposes, including writing, printing, packaging, cleaning, a number of industrial and construction processes.

2.5 Paper pulp

The papers, which were collected, cannot be utilized immediately. It should be made into a paper pulp before mixing with other ingredients. The papers were kept in the water tank for 2 to 3 days, otherwise until the papers degrade into a paste-like form. Then the paper was taken out of the water and taken to the mixer machine to make it as a paper pulp and subjected to medium rotation for not less than 1 min.

2.6 Water

Potable water should be used for both soaking and mixing of concrete. It should be free from organic matter and the pH value should be between 6 and 7.

3. Material properties

Table -1: Properties of Cement

S.NO.	TEST	RESULTS OBTAINED
1	Initial setting time	80 minutes
2	Final setting time	300 minutes
3	Consistency	30%
4	Specific gravity	3.15

Table -2: Properties of Fine aggregate

S.NO.	TEST	RESULTS OBTAINED
1	Fineness modulus	2.50
2	Specific gravity	2.48

Table -3: Properties of Coarse Aggregate

S.NO.	TEST	RESULTS OBTAINED
1	Fineness modulus	7.17
2	Specific gravity	2.70

Table -4: Chemical composition of Paper Pulp

Element	Percentage Content
Ca	14.93
Si	60.54
O	15.82
S	1.10
Mg	3.60
K	0.20
Al	2.05
Na	0.23
Fe	0.91

4. EXPERIMENTAL PROGRAMS

4.1 Slump Test (Workability of Fresh Concrete)

The internal surface of the mould was cleaned and the oil was applied. The mould was placed on a smooth horizontal non- porous base plate. The mould was filled with the prepared concrete mix in 4 approximately equal layers. Each layer of the concrete specimen was tamped by using tamping rod with 25 strokes of the rounded end of rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer. The excess concrete was removed and The surface was leveled with a trowel. The water was leaked out with the base plate and the mould. The mould was increased by the concrete instantly and slowly in vertical direction. The slump was measured as the difference between the height of the mould and that of height point of the specimen was tested. The above operation was carried out at a place free from shocks or vibrations and within a 2 minutes time after sampling.

4.2 Compressive Strength Test

For cube test, two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate was used. For most of the works cubical moulds of size 15cm x 15cm x 15cm was used. This concrete was poured in the mould and tempered properly so as not to have any voids. The moulds were removed and test specimens were putted in water for curing after 24 hours. The top surface of these specimens were made even and smooth. This was done by putting cement paste and was spreading smoothly on whole area of specimen. These specimens were tested by compression testing machine after 7 or 28 days of curing. Load was applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Compressive strength of concrete is equal to the divition of load at failure and the area of specimen.

4.3 Split Tensile Strength Test

For the determination of splitting tensile strength of the paper pulp concrete specimens, cylinder specimens of diameter to length ratio 1:2 was selected, with diameter as 150 mm and the length as 300 mm. After 28 days of curing , the specimens were dried in open air and it was subjected to split tensile test under UTM (Universal Testing Machine). The rate of loading was adjusted as 0.11 to 0.023 MPa/sec as per ASTM C496-90. While testing the specimens, plywood pieces one at the top and the other at the bottom.

4.4 Flexural Strength Test

The flexural strength of concrete mixes with various percentages of paper pulp was determined by using the

beam specimen of size 100mm x 100mm x 500mm. Specimens were dried in open air after 28 days of curing and it was subjected to flexural strength test. The load was applied at a rate that constantly increases the maximum stress until rupture occurs. The fracture indicated in the tension surface with in the middle third at span length. Finally the flexural strength is calculated by using simple bending equations the bending stress,

$$\sigma = Pl/bd^2 \ (N/mm^2),$$

where,

P = load at failure (N)
d = depth of specimen (mm)
l = length of specimen (mm)

5. RESULTS AND DISCUSSIONS

5.1 Slump Test on Fresh Concrete for Workability

The workability of fresh concrete is determined by Slump test. By adding the paper pulp with cement , the workability of fresh concrete decreased. Because, the paper exhibited a high water absorption capacity. When a higher amount of paper pulp was added in the concrete mix , it require more water for achieving a given slump. The workability of paper pulp concrete was improved by the addition of high amount of water instead of admixtures to achieve the economical concrete. The main reasons for the reduction of workability of concrete are the amount of addition of paper pulp, physical properties and the carbon content.

Table -5: Slump test

S.NO.	% ADDITION OF PAPER PULP	SLUMP VALUE (mm)
1	0	80
2	5	78
3	10	75
4	15	72

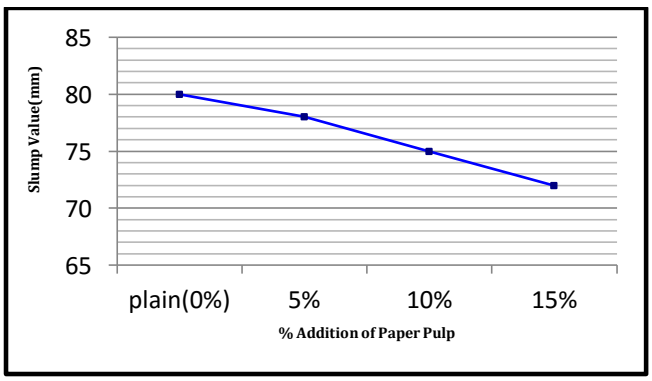

Chart -1: Slump cone test

5.2 Compressive strength test

Compressive strength increases initially on addition of the paper pulp, but it was decreased significantly on further addition of the paper waste. The results of compressive strength of different percentages are summarized in Table.

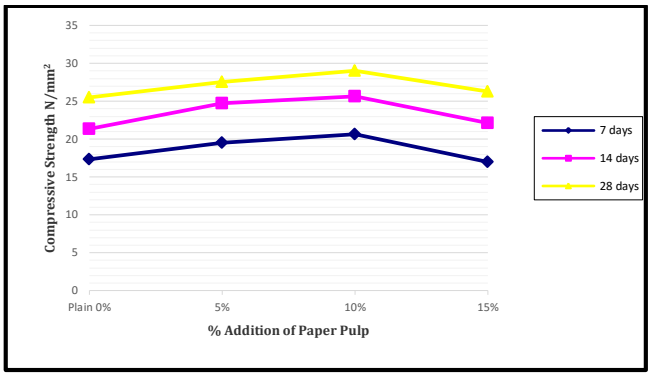

Chart -2: Compressive strength test

Table -6: Compressive strength test

%ADDITION OF PAPER PULP	COMPRESSIVE STRENGTH (f_{ck}) N/mm²		
	7th day	14th day	28th day
0	17.32	21.34	25.50
5	19.54	24.76	27.57
10	20.67	25.65	28.99
15	16.98	22.10	26.31

In 7th ,14th ,28th day curing the compressive strength values were increased upto 10% addition of the paper pulp. Further addition of paper pulp the flexural strength values were decreased.

5.3 Split Tensile Strength Test

Splitting tensile strength was found to be more than that for reference mix at 10% addition of paper pulp. Splitting tensile strength decreased with increasing waste paper pulp content.

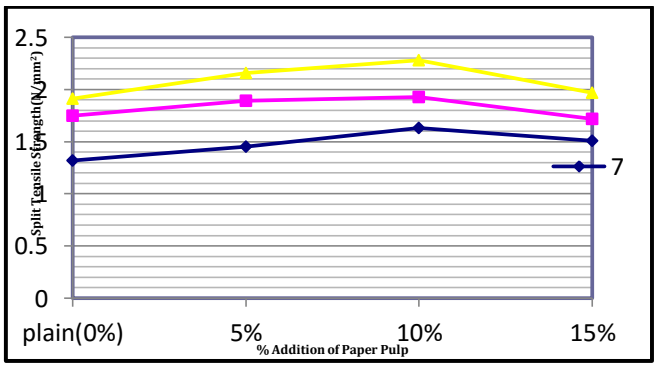

Chart -3: Split tensile strength test

Table -7: Split tensile strength test

%ADDITION OF PAPER PULP	SPLIT TENSILE STRENGTH (f_{ck}) N/mm²		
	7th day	14th day	28th day
0	1.32	1.75	1.91
5	1.45	1.89	2.16
10	1.63	1.93	2.28
15	1.51	1.72	1.97

In 7th ,14th ,28th day curing the split tensile strength values were increased upto 10% addition of the paper pulp. Further addition of paper pulp the flexural strength values were decreased.

5.4 Flexural Strength Test

In 7th ,14th ,28th day curing the flexural strength values were increased upto 10% addition of the paper pulp. Further addition of paper pulp the flexural strength values were decreased.

Table -7: Flexural strength test

%ADDITION OF PAPER PULP	FLEXURAL STRENGTH (f_{ck}) N/mm²		
	7th day	14th day	28th day
0	2.9	4.3	5.1
5	3.3	4.6	5.9
10	3.9	5.1	6.5
15	3.1	4.8	6.2

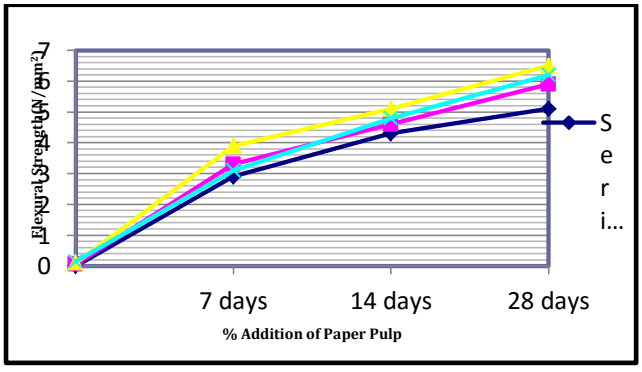

Chart -3: Flexural strength test

5. CONCLUSIONS

The main objective of this project is to evaluate the structural innovative concrete using waste paper. To assess this, series of laboratory tests were conducted on various concrete mixes by the addition of paper pulp. The strength characteristics of paper pulp concrete have been studied. The following conclusions are drawn from the experimental investigations;

The Slump value increased when the paper pulp was added upto 10% for cement, above 10% addition of paper pulp, the slump decreased as the paper pulp content in the concrete mixtures was increased.

Concrete mixes containing 5% and 10% of paper pulp, have shown an increase in compressive strength and split tensile strength when compared to control mix and there was a decrease on addition of 15% of paper pulp.

The decrease in compressive, tensile and flexural strength with the increase in percentage of paper pulp is due to the presence of low silica content in the composition which tends to decrease in its strength. The use of paper pulp in concrete is not only for decreasing the environmental pollution but also to decrease the cost of construction economically. This is the best way to dispose the paper waste in an effective manner.

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