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Utilization of Waste Paper Pulp in Construction

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ABSTRACT: *Nowadays concrete plays a major role in the development of any country. It has become in such a way that the usage of concrete became second only to water around the world. In the last two decades environmental issues in the concrete industry have been paid a lot of attention, aiming at reducing the total environmental impact of concrete structures to a minimum, without compromising on their performance. A lot of different tools have been developed in order to reduce the environmental impact of concrete.*
Over 300 million tons of industrial wastes are being produced per annum by chemical and agricultural process in India. These materials possess problems of disposal problem. Paper fibers can be recycled only a limited number of times because the fibers become too short to make high quality paper. It means low- quality paper fibers are separated out to become waste sludge. Paper sludge have properties like cement because of the presence of silica and magnesium which improve the workability of the concrete. The amount of sludge generated by a recycled paper mill is greatly dependent on the type of furnish being used and end product being manufactured. Paper sludge can be used as an alternative for the partial replacement of fine aggregates in production of concrete.
About 300 kg of sludge is produced for each tone of recycled paper. This is an enormous volume of sludge produced every day that makes landfill decomposition uneconomical. By using the right proportion of mixes, concrete mixtures containing the paper sludge can be produced that are equivalent in slump and strength with respect to concrete without paper sludge.

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I. INTRODUCTION

Use of the industrial wastes in the construction work might lead to a finding the possibility to decrease the environment pollution by paper industry wastes and it will also bring down the cost of construction. The use of paper sludge in concrete used as an alternative to landfill disposal.

The dry paper sludge mainly contains silica and calcium oxide, followed by alumina and magnesium oxide. Cement mixed with 10% and 20% calcined paper sludge exhibits a small decrease in compressive strength than the ordinary Portland cement. A study on the reuse of paper de-inking sludge, undertaken in Spain, shows its potential as raw material for yielding a product with pozzolanic activity.

Although there are potential advantages of including paper-mill residuals in a concrete mixture, such as cost savings in both waste management and concrete production, to date still lot of work has to be done on the utilization of paper pulp in concrete production. This thesis work summarized the behavior of concrete with the waste paper sludge by replacement of cement in the range of 5%, 10%, 15% and 20% which may helps to reduce the disposal problem of sludge and enhance the properties of concrete.

In this project, waste paper pulp from pulp and paper mill industries is used as the partial replacement of the cement, zone-II sand is used as a fine aggregate and stone as a coarse aggregate to produce the concrete. The cement and paper pulp bind the loose coarse aggregates, fine aggregate sand other un-reacted materials together to form the concrete, with or without the presence of admixtures. The manufacture of concrete is carried out using the basic concrete technology methods.

As in the case of OPC concrete, the paper pulp-based concrete, the aggregates occupy the 75-80% by mass. The mixture of coarse and fine aggregates was mixed thoroughly first, then cement is added and mixed thoroughly after that waste paper pulp is added to the mix and water is added and thoroughly mixed.

II. MATERIAL AND METHODS

Materials

Paper pulp

In this thesis work an attempt is made to produce the concrete specimens constituting calcined source material (waste paper pulp). Curing for the specimens is carried out at room temperature.The paper pulp used in the experiment is taken from Dhanlakshmi paper mill, Dongargaon, Rajnandgaon.

Fine aggregate and coarse aggregate
Zone-II sand was considered for work and the properties of zone-2, fine aggregate was shown in table and machine crushed stone used as coarse aggregate. The size of aggregate varies from 20mm to 4.75mm.

Water
Portable water supplied by the college was used in the work. The pH of water around 6.5-7.
Mix design
M20 & M25 Grades of Concrete were considered. Mix of M25 were designed by using IS 10262.The mix proportions corresponding to M20 are 1:1.40:3.20:0.45 and M25 are 1:1.26:2.80:0.45.

Testing of specimen
Compressive strength

The cube specimens were tested on compression testing machine of capacity 1000kN. The bottom surface of the compression testing machine was cleaned and loose fine particles removed from the surface of the cubes.The mould was placed on the bottom surface of machine in such a way that the load was applied to opposite sides of the cubes as cast that is not top and bottom. The axis of the specimen was aligned in the centre of the loading frame. The load was applied on the specimen and it was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer cubes can sustain. Then, the maximum load applied on the specimen was recorded.

Split tensile strength

The cylindrical specimens were tested on compression testing machine of capacity 1000kN for getting the tensile strength. The bottom surface of the machine was cleaned off and in case of cylindrical specimen the test was carried out by placing the specimen horizontally between the loading surfaces of the compression testing machine for split tensile strength and the axis of the specimen was aligned at the centre of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on the specimen was noted.The Split Tensile Strength is obtained for

$$\mathbf{fst = 2P/(\pi LD)}$$

Where, P is the maximum load carried by the cylinder
L is the length of the cylinder
D is the diameter of the cylinder

Flexural strength

Flexural strength of the specimen was determined with the help of universal testing machine of 1000 KN capacity and $\pm$80mm stroke (displacement).

The flexural strength of the prism specimen is expressed as the modulus of rupture. The two point loading method is used for the testing.The test specimen should be turned its sides with respect to its portion moulded and cantered on bearing blades. All the tests were performed under vertical displacement control. The load deflection curves were continuously recorded for each prisms of all four different percentages of crumb rubber If "a" equals the distance between the line of fracture and the nearer support measured on the cantered line of the tensile side of the specimen, in cm, is calculated to the nearest 0.05 M pa as follows.

$$\mathbf{F = Pl/(bd^2)}$$

When "a" is greater than 20.0 cm for 15cm specimen or greater than 13.3 cm for a 10.0cm specimen or

$$\mathbf{F = 3Pa/(bd^2)}$$

When "a" is less than 20.0cm but greater than 17cm for 15cm specimen or less than 13.3cm but greater than 11cm for a 10cm specimen
Where, b = measured width of the specimen
d = measured depth of the specimen at the point of failure
l = length of span on which the specimen was supported
P = Max. Load in kg applied to the specimen upto failure.

Sorpitivity study

The sorptivity tests were carried out on all batches of Paper Pulp based Concrete with size of 15x15 x15cm. The preparation of samples also included water impermeability of their lateral faces, reducing the effect of water evaporation. The test started with the registration of samples weight and afterwards they were placed in a recipient in contact with a level of water capable to submerge them about 5 mm. After a predefined period of time, the samples were removed from the recipient to proceed to weight registration. Before weighing, the samples superficial water was removed with a wet cloth. Immediately after weighting, the samples were

replaced in the recipient till reach the following measuring time. The procedure was repeated, consecutively, at various times such as 15 min, 30 min, 1 h, 2 hrs, 4 hrs, 6 hrs, 24 hrs, 48 hrs ,72 hrs, 7days, 14days and 28days.

III. EXPERIMENTAL PROGRAM AND METHODOLOGY

Table 1 Showing Mix proportions and quantity of materials used for M20 Mix 'A'

S.No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Cement	365.94	7.41
2	Fine Aggregate	539.28	10.92
3	Coarse Aggregate	1232.64	24.96
4	Waste Paper Pulp	19.26	0.39
5	Water	173.34	3.51
	Density	2332	

Table 2 Showing Mix proportions and quantity of materials used for M25 Mix 'A'

S.No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Cement	405.17	8.20
2	Fine Aggregate	537.39	10.90
3	Coarse Aggregate	1194.20	24.20
4	Waste Paper Pulp	21.33	0.431
5	Water	191.92	3.89
	Density	2372	

Table 3 showing Mix proportions and quantity of materials used for M20 Mix 'B'

S.No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Cement	346.68	7.02
2	Fine Aggregate	539.28	10.92
3	Coarse Aggregate	1232.64	24.96
4	Waste Paper Pulp	38.52	0.780
5	Water	173.34	3.51
	Density	2332	

Table 4 Showing Mix proportions and quantity of materials used for M25 Mix 'B'

S.No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Cement	383.85	7.77
2	Fine Aggregate	537.39	10.90
3	Coarse Aggregate	1194.20	24.20
4	Waste Paper Pulp	42.65	0.863
5	Water	191.92	3.89
	Density	2372	

Table 5 showing Mix proportions and quantity of materials used for M20 Mix 'C'

S.No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Cement	327.42	6.63
2	Fine Aggregate	539.28	10.92
3	Coarse Aggregate	1232.64	24.96
4	Waste Paper Pulp	57.78	1.17
5	Water	173.34	3.51
	Density	2332	

Table 6 Showing Mix proportions and quantity of materials used for M25 Mix 'C'

S.No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Cement	362.52	7.34
2	Fine Aggregate	537.39	10.90
3	Coarse Aggregate	1194.20	24.20
4	Waste Paper Pulp	63.98	1.30
5	Water	191.92	3.89
	Density	2372	

Table 7 showing Mix proportions and quantity of materials used for Mix 'D'

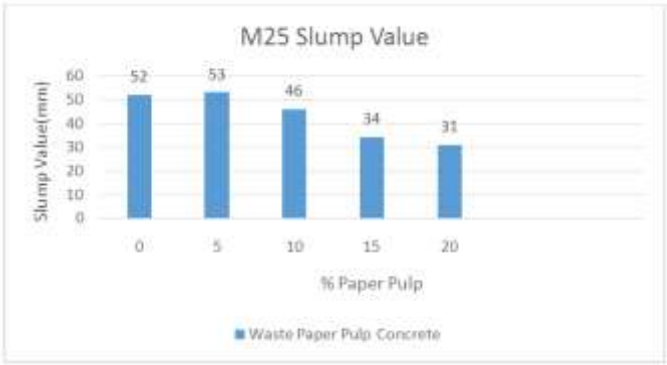
S.No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Cement	308.16	6.24
2	Fine Aggregate	539.28	10.92
3	Coarse Aggregate	1232.64	24.96
4	Waste Paper Pulp	77.04	1.56
5	Water	173.34	3.51
	Density	2332	

Table 8 Showing Mix proportions and quantity of materials used for M25 Mix 'D'

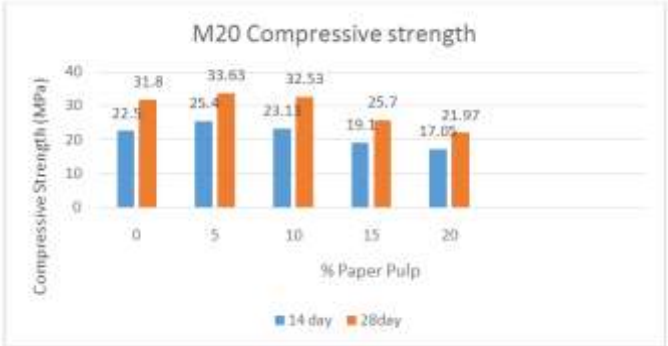
S.No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Cement	341.20	6.91
2	Fine Aggregate	537.39	10.90
3	Coarse Aggregate	1194.20	24.20
4	Waste Paper Pulp	85.30	1.72
5	Water	191.92	3.89
	Density	2372	

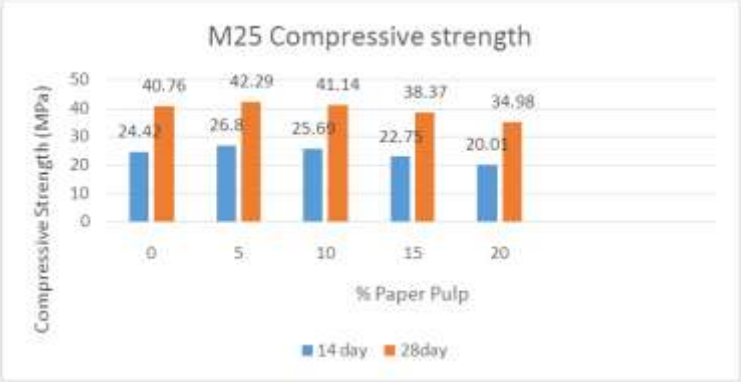
IV. RESULTS

Workability of concrete



Compressive strength of cubes

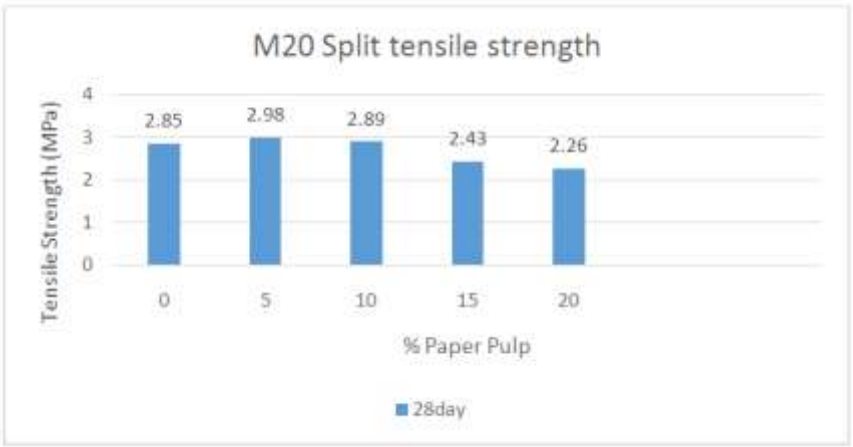


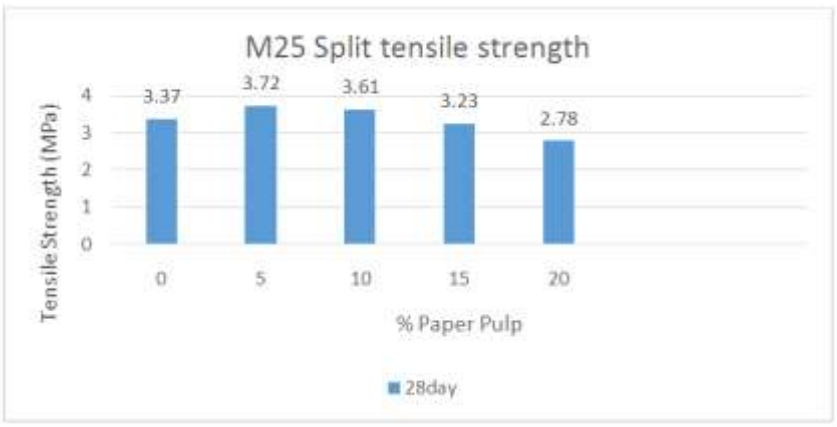


For concrete cubes cured for 28 days, the strength reached around 33.63 MPa.

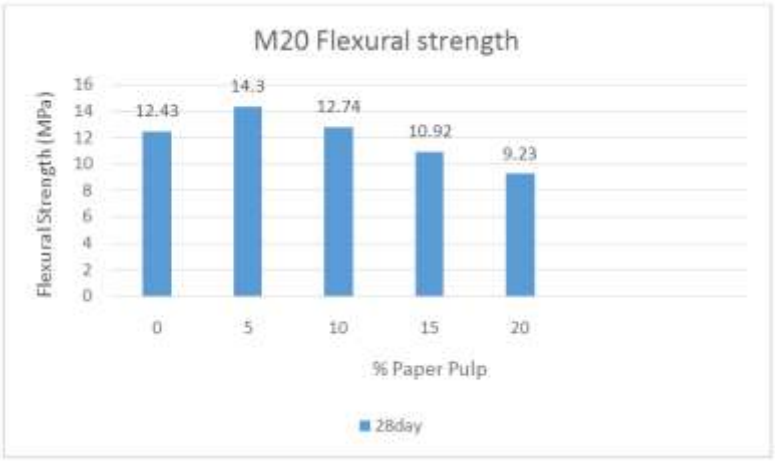
For concrete cubes cured for 28 days, the strength reached around 42.29 MPa.

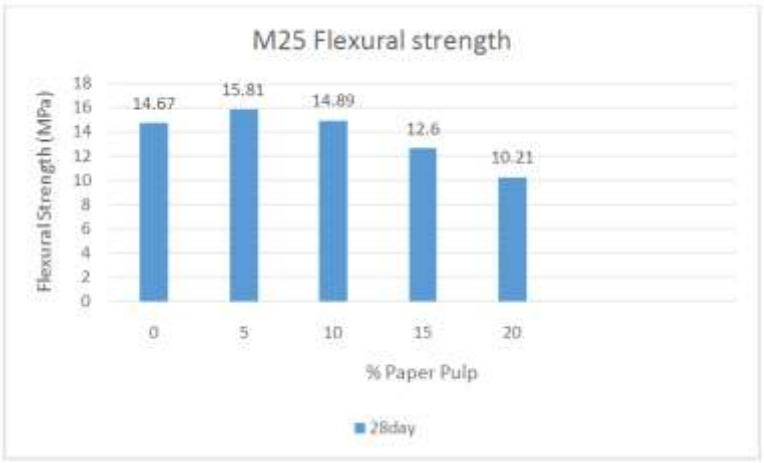
Split tensile strength of specimen





Flexural strength of cubes





V. DISCUSSION AND CONCLUSION

From the experiments conducted on the paper pulp-basedconcrete developed in the concrete laboratory of SSTC, the following conclusions have been made.

1. The slump value till the 5% replacement the slump value was increased by 5%.
2. The waste paper pulp concrete mixes,had 10% and 15% of paper waste, had shown decrease in slump 6%. Further when waste paper pulp quantity increased by 20%, the slump value decreased by 12%.
3. The compressive strength, split tensile strength and flexural strength increased till the 10% replacement of cement with paper pulp after that it gradually decreases.
4. The compressive strength decreased by 2.1% after the 20% replacement of cement with waste paper pulp.
5. The suitable replacement of cement with waste paper pulp is 5 to 10%.
6. The water absorption of the concrete cubes containing 10%, 15% and 20% waste paper pulp was increased by 0.1%, 0.2% and 0.4%.
7. It will help to counteract the problem of disposal of waste paper pulp for the paper industry and in addition to that it will also help in preparing greener concrete.
8. Density of concrete mix with 10% and 15% paper waste increased by 0.5% and 0.2% respectively compared to control mix but it decreased by 0.1% with 20% of paper waste.
9. It can be concluded that an application of 10% of waste paper pulp, to concrete mix may be conveniently allowed.
10. The cost of production of concrete, when compared with control mix gets reduced by 1.7%, 2.4% and 3.2% with addition of 10%,15% and 20% waste paper pulp respectively.

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