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Mechanical Properties and Flexural behavior of Papercrete Concrete

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Abstract: *A sustainable concrete structure is constructed to ensure that the total environmental impact during its life cycle, including its use, will be minimal. Sustainable concrete should have a very low inherent energy requirement, be produced with little waste, be made from some of the most plentiful resources on earth, produce durable structures, have a very high thermal mass, and be made with recycled materials. In present investigation the experimental work was carried out to find the mechanical properties of concrete by paper as partial replacement of cement. The specimens were produced with percentage replacements of cement with 1%, 2.5%, 5%, 7.5% and 10 % of paper. Moreover, a control mix with no replacement of the cement was produced as baseline data. The Test program consisted of six beams. The span of all beams is 1500 mm and cross section is 150 x 200 mm.All beams are tested as simply supported and subjected to three point loading symmetrically placed at equal distance from the centreline of the beam. The flexural behaviour PCB has analysed experimentally with a variation in interface as 50% and 100% from bottom with paper concrete has prepared with replacement of cement by 2.5% with waste paper for M25 of concrete The obtained results indicated that the strength of PC beams was higher than that anticipated from the rule of mixtures. The load deflection curve shows that the mid span deflection of PC beams are less when compared to control beams at all load levels.. As PCB is economical, having more durability and strength, so its adoption enables more sustainability in concrete industry.*

Keywords: *Papercrete concrete beam, Sustainable concrete, Flexural Strength.*

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I. Introduction

Currently India has taken a major problem with waste disposal through landfills. Cement and river sand, which is one of the constituent used in the production of conventional concrete, has become highly expensive and also scarce. In the backdrop of such a bleak atmosphere, there is large demand for alternative materials from the industrial waste and municipal waste.Most of the municipal and industrial waste has been disposed of in landfills. However, the increasing refusal of communities to have landfills nearby, as well as the increased pressure from environmental agencies to require proper waste management is creating the need for alternative final disposal consistent with environmental needs at a rational cost .The re-use of wastes is important from different points of view, It helps to save and sustain the natural resources which are not replenished, it decreases the pollution of the environment and it also helps to save and recycle energy in production process .The productive use of wastes material represents a way of solving some problems of solid waste management.Papercrete concrete is a new composite material using waste paper as a partial replacement of portland cement. By using the waste paper, papercrete concrete is not only reducing the amount of cement using but also making environmentally friendly building materials. Newspaper was used for this experiment among lots of waste papers . Paper mainly consists of cellulose fibre and inorganic materials so it used binder by replacing with cement because it was expected that cellulose fibre of newspaper combine well with cement paste well.The Papercrete concretes are affordable, cost effective and withstand for more pressure, impact and temperature when compare it with conventional concrete. It is observed that the Papercrete Concrete is weak in compressive. But it have good flexural strength and split tensile strength.

II. Experimental investigation

Materials

Materials Cement used for the experiment program was Ordinary Portland Cement of 43 grade whose specific gravity was 2.91, the nominal size of the coarse aggregate used is 20 mm and fine aggregate used is river sand. The superplasticizer was Supaflo SPL (P) (043) high range water reducing admixture.

Mix design

The concrete of M25 grade was designed as per IS 10262-2009.Super plasticizer is added to obtain workability. Concrete mixes were prepared with paper in 0%, 1%, 2.5%, 5%, 7.5% and 10% replacing cement and cubes, cylinders and beams with 2.5 % replacement were cast.

Table 2: *MixProportion*

Cement(kg/m^3)	Fine aggregate(kg/m^3)	Coarse aggregate(kg/m^3)	Water(l/m^3)	Super plasticizer(l/m^3)
357	681.5	1252	186	3.52

Casting and curing

The beam specimens of size 100mm × 100mm × 500mm and cube specimens of size 150mm and cylinders of size diameter150mm,height300mm for M25 grade conventional concrete were cast with mix proportion of 1:1.9:3.5 and water cement ratio of 0.52. A total of 6 cubes, 6 cylinders and 6 beams were casted for each proportions of paper content.Super plasticizer was mixed for two minutes to get a homogenous mix.. The specimens were compacted for two minute on the table vibrator. The surface of concrete was finished using a trowel. The specimens was demoulded after 24 hours and then placed in the curing tank. The curing of specimen was carried out for 28 days.

Beams

The experimental study consists of casting of three groups of reinforced concrete (RC) beams. In group A two control beams weak in flexure were casted. In group B two beams were casted having half of the depth of beam caste with 2.5% paper replacement concrete and remaining depth made with normal concrete. In group C two beams were cast with 2.5% paper replacement over entire volume of beam. Cast beams are covered with gunny bags and done wet curing. The span of all beams is 1500 mm. The cross section is 150 x 200 mm. All beams are under reinforced sections. These beams are reinforced with 2bars of 10mm diameter steel bars in tension side and 2bars of 8mm diameter steel bars in compression side. All beams were provided with 8φ mm steel stirrups @ 140 mm center to center

Tests

slump test was used to determine workability of papercrete concrete. The mechanical properties such as compressive strength, split tensile strength and flexural strength was conducted at 7 and 28 days.two point loading test was done on beams.

III. Results

1. Workability

From theslumpcone test, itisobservedthattheworkability isdecreasing withincrease ofpapercontent.Fromtheslu mpvaluesitisobservedthatafter5%replacement,theworkabilityisrapidlydecreasing.

2. Compressive strength

Compression test according to IS: 516(1959) was carried out on the 150 x 150 x 150 mm cubes were tested for the compressive strengths of concrete specimens were determined after 28 days of standard curing. For papercrete concrete, the results show that the addition of paper waste resulted in a significant reduction in concrete compressive strength compared with the control concrete. This reduction increased with increasing percentage of paper content. Losses in compressive strength were noticed.

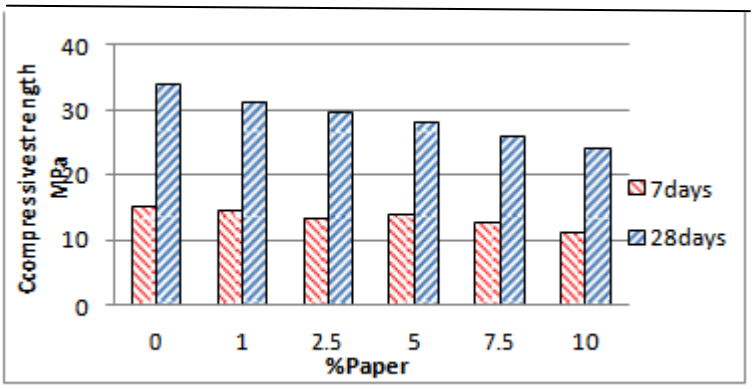

Fig. 1: *CompressiveStrength of Papercreteconcrete*

3. Splittensilestrength

Split tensile test according to IS: 5816 (1999) was carried out on the cylindrical specimens of diameter 150 mm and length 300 mm [9]. The split tensile strengths of concrete specimens were determined after 7 and 28 days of standard curing. The split tensile strength results for different paper waste content in the mixes and conventional concrete shows that strength was increased upto 2.5% replacement and it was decreased rapidly after 5% replacement.

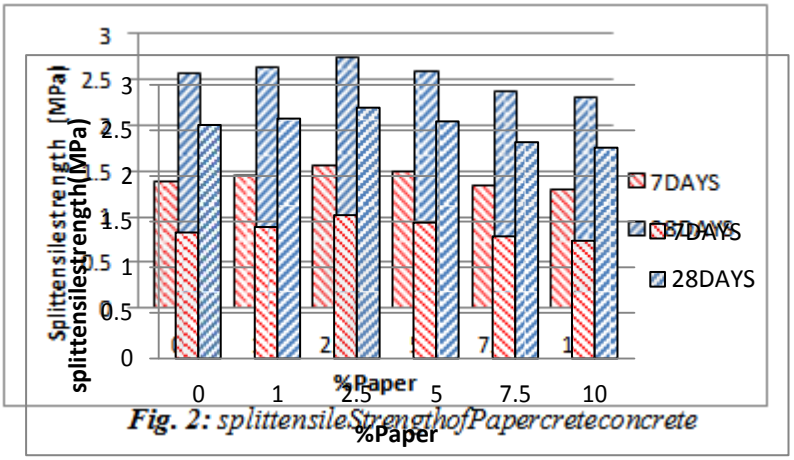

Fig. 2: *splittensileStrengthofPapercreteconcrete*

4. Flexuralstrength

The flexural strength of papercrete concrete and conventional concrete, beams were obtained by conducting flexural test on specimens of size 100x100x500mm by two point load method [9].As the percentage of replacement with paper is increases, flexural strength is increases upto 2.5% replacement compared to conventional concrete and decreases ,may be due to improper bonding of paper particles with aggregates.

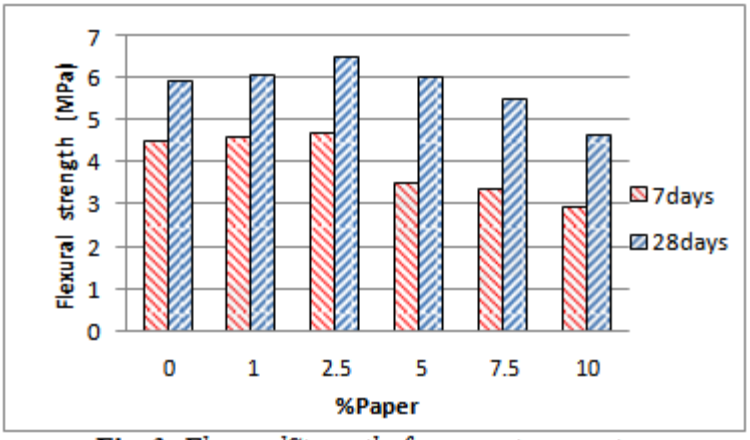

Fig. 3: *FlexuralStrengthofpapercreteconcrete*

5. Young's modulus of elasticity

Test specimen shall be a right circular cylinder with dimensions of 150 x 300 mm The specimen shall be tested at moisture contents as close to field conditions as possible. The cylindrical surface shall be smooth and free from abrupt irregularities and straight to within 0.3 mm over the full length of the specimen and the dimensions of the specimen shall not vary by more than 0-2 mm over the length of the specimen. from the test results the young's modulus of elasticity is found to be 23164.98 Mpa for control and 25563.8 Mpa for papercrete concrete.it was found that for papercrete ,8% is
grater than normal concrete.

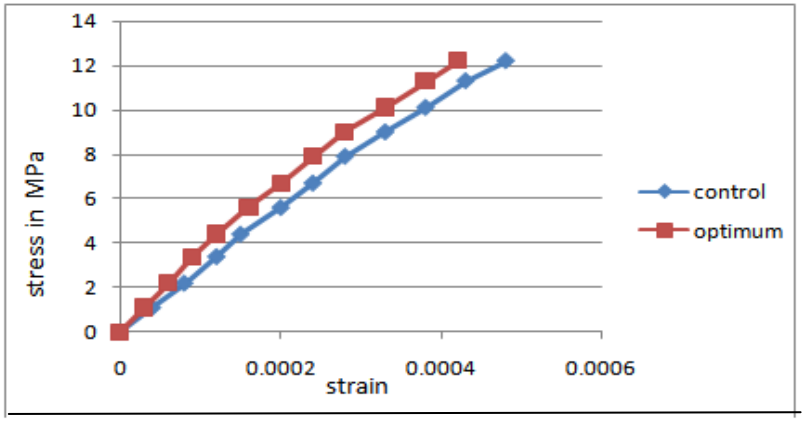

Fig.4 Sress vs Strain graph

IV. Experimental Results of Beam

Ultimate Load at Failure

Threes groups of beams were tested for their ultimate strengths. In group A two beams CB1, CB2, are tested. In group B two beams P1, P2, are tested. In group C two beams PC1,PC2 are tested. It was observed that load carrying capacity of group A beams; group B beams are lesser than the group C beams.

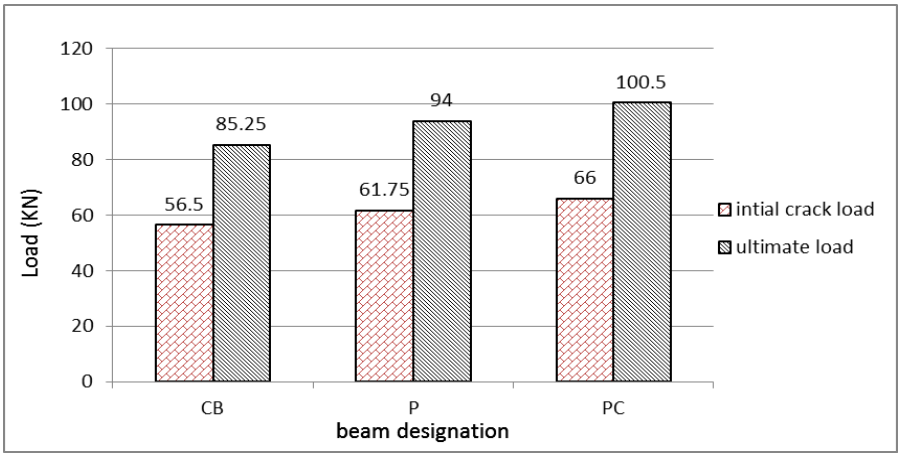

Fig.4 Comparison between Initial crack Load & Ultimate Load of all Beams

Load-Deflection Behaviour:

The load-deflection behaviour of all the beams was recorded. The mid-span deflection of each beam was compared with that of their respective control beams. It was noted that the deflection of PC beams showing better results than those of corresponding control beams.

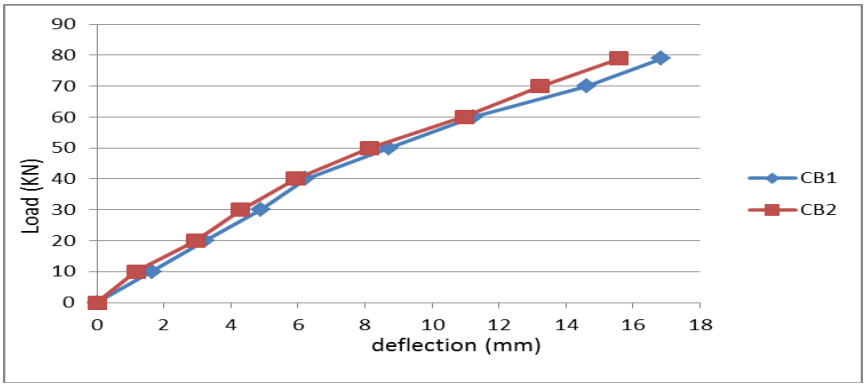

Fig.5 Load Vs. Deflection Behaviour for Group A beams

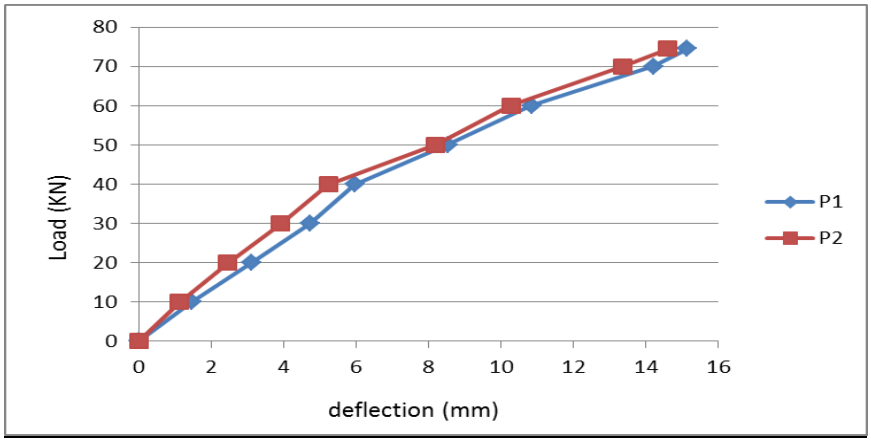

Fig.6 Load Vs. Deflection behaviour for Group B beams

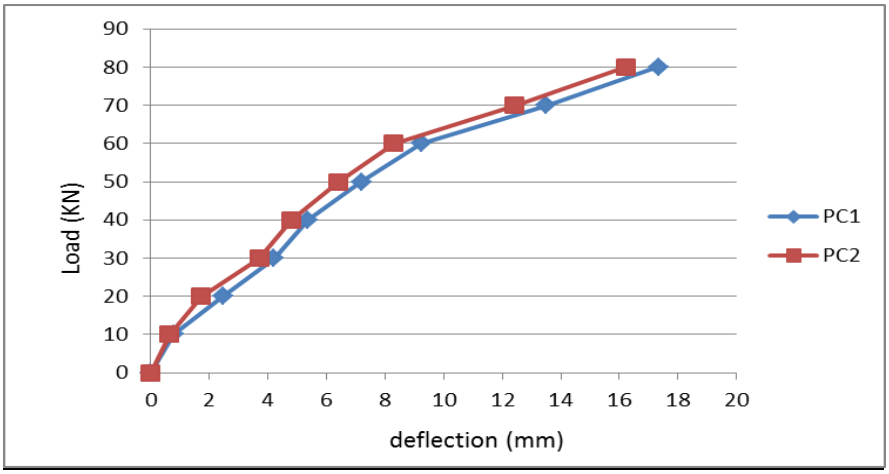

Fig.7 Load Vs. Deflection behaviour for Group C beams

Cracking and mode of failure:

All of the beams tested failed in flexure with crushing of concrete in the compression zone at the failure stage after the development of flexural cracks. Group C beams recorded less number of cracks and lesser crack width compared with the Group A & Group B beams. This may indicate that the paper replacement beams shows better cracking behaviour compare to normal beam.

Fig.8 cracking pattern of beams

➢ The reasons for reduction in the strength of concrete when paper replaced is more as follows:-

- Lack of proper bonding between paper particles and cement paste when replacing of paper content was more.
- May be due to non-uniform distribution of paper particles in the concrete, non- homogenous samples are produced, which in turn results in reduction in concrete strength.
- The workability of concrete is greatly influenced by the percentage replacement of paper.
- From the slump values it is observed that after 5% replacement ,the workability is rapidly decreasing.
- The compressive strength from the 7 days & 28 days results shows that it is decreasing with increase of

paper content.

- The load deflection characteristics obtained for the controlled beams and PC beams are almost similar curvature. The first cracking and ultimate load (100.5kN) of PC beams are higher when compared to controlled beams (85.25 KN)
- Beyond the peak load, the no. of flexural cracks stabilized and the cracks at the mid-span opened widely thereafter with the yielding of steel.
- The failure in all the cases was initiated by yielding of the tensile steel followed by the crushin--g of concrete in the compression face.

V. Conclusion

Based on the experimental investigations carried out, the following conclusions are drawn.

- Utilization of waste paper in concrete is an effective method of disposal of this waste, as they cannot be used in land disposal
- For papercrete concrete, the test results show that the addition of paper resulted in a significant reduction in concrete compressive strength compared with the control concrete. This reduction increased with increasing percentage of waste paper. Losses in compressive strength ranging from 7.98 % to 24 % were observed.
- From the flexure & split tensile test results ,the strength is increasing upto 2.5% replacement ranging from 3.3% to 8.3% &3.7% to 11.5 for 28 days.
- Increase in flexural strength was achieved in the replacement amount of 2.5% of cement with waste paper contents.
- Experimental results shows that ultimate load carrying capacity of PC beams are increased due to the paper fibre in the concrete.
- The ultimate load carrying capacity of PC beams approximately 17.5 % more than that of controlled beam and 10% more compared to P1 and P2 beams.
- The load deflection curve shows that the mid span deflection of papercrete concrete beams are less when compared to Control beams at all load levels.

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