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Papercrete concrete

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ABSTRACT-*The majority of abandoned paper waste accumulating from the countries all over the world causes certain serious environmental problems. The high volume of concrete offers a holistic solution to the problem of meeting the increasing demands for concrete in the future in a sustainable manner and at a reduced cost. At the same time, it is necessary to reduce the environmental impact of industries that are vital to economic development The present study focuses on utilizing the waste materials like wastepaper and flash into cost effective building bricks and recycle the waste paper without any environmental problem to the surrounding environment and the society The investigation was carried out to evaluate the strength durability and structural properties of fly ash based Paper Crete building bricks. Then the results were compared with those of conventional bricks. The behavior of paper Crete masonry unit was studied and their results were verified with software analysis (ANSYS).The strength and durability of cement composites containing wastepaper, fly ash, rice husk ash and micro silica have been studied in detail and the optimum mix proportions have been obtained. This optimum mix was considered for casting the fly ash basedpaper Crete bricks and their properties have been studied. In order to improve the durability property (water absorption) several techniques have been tried and a suitable technique was arrived at for further study of coated fly ash based papercrete bricks .Thepaper Crete bricks have been tested for their compressive strength, water absorption, thermal conductivity, sorptivity and acid resistance. The performance of the papercrete has been compared with that of conventional clay bricks. As a final part of the research, the behavior of brick masonry walls has been studied under lateral loading. The results were compared with that of theoretical values predicted by ANSYS software .The thesis concluded that the paper Crete bricks are relatively low cost, light weight and more flexible and they are most suitable for earthquake prone areas. This brick does not expand or contract so that the sheets of glass or glass block can be embedded and trimmed with paper Crete. However, uncoated bricks are not suitable for water logging and external walls. They can be used in inner partition walls. The uses of paper Crete brick masonry not only result in reduced dead load of the structure, it also offers higher ductility and*

energy characteristics. Therefore, the paper Crete bricks are suitable material for earthquake prone areas.

1 INTRODUCTION

Cement is the largest utilized man-made material in world. For concrete manufacturation a large amount of cement is being used in India. The amount of total cement consumption in India for year 2017 was 270m million metric tons and it is excepted to go up to 273 million metric tons by the year 2019. Requirement of cement increase per year.

The production of cement is not only costly and energy intensive, but it also produces large amount of carbon emission. The production of one one ton of cement produces approximately one ton of CO_2 in the atmosphere.

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 .These fibers from paper add strength to cement, just as glass fibers add strength to fiberglass. In the case of papercrete, these fibers can actually make up the bulk of the mix, resulting in a product that is both lightweight and strong.

Paper is principally wood cellulose. Cellulose is natural polymer. The cellulose chain bristles with polar-OH groups. These groups form hydrogen bonds with-OH group on adjacent chains, bundling. and the chain together. In order to form a hard and a stable crystalline region, the chains are packed .regularly so that the bundled chains gain more stability and strength.

1.2. OBJECTIVE

1. Comparison between compressive strength of normal concrete and papercrete concrete.
2. Effect of 100^0ctemperature on papercrete concrete.

1.3. METHODOLOGY

1. Design of concrete mix for M30 grade.
2. Casting of concrete cubes having size of 150x150x150mm by replacing of cement with paper by 0%, 5%, and 10% respectively.
3. Curing of concrete cubes for 28 days in normal water.
4. Testing of concrete cubes for compressive strength after 7 days and 28 days by using UTM having capacity of 1000KN.
5. Heating of concrete cubes at 100^0c temperature and testing for weight loss.

1.4 RESOUSE INDUSTRY FOR PAPER PULP

Resource of paper pulp:-

1. Ashti, Gadchiroli, Maharashtra.
2. Bhigwana, pune district, Maharashtra.
3. Sewa, jeypore, orisa.
4. Ballarpur or Ballarshah, chandrapur district, Maharashtra.
5. Yamuna nagar, tamunanagardistrict , Haryana
6. Kamalaouram, warangalidistrict ,telangana.

2.LITERETURE REVIEW

1. "Conducted a research to determine whether or not papercrete has suitable mechanical and physical properties". (2006) .by, Fuller.

The parameters that he studied are the Young's modulus (E), thermal conductivity (K), thermal resistance (R), bond characteristics, and creep behavior. The stress versus strain graphs suggest that papercrete is a ductile material that can sustain large deformations. Cement plays an important role in the compressive strength and behavior. Specimens with higher proportion of cement exhibit larger Young's modulus.

2. "Investigation on the viability of using paper mill sludge as an alternative material". (2006).by, Gallardo et al. focused.

This can be applied as a partial replacement of fine aggregates in manufacturing fresh concrete intended to be used for low cost housing project. Based on the results of this study, they concluded that the most suitable mix proportion is 5 to 10% replacement of paper sludge to fine aggregates used. Any further percentage replacement higher than 10% would result in a decrease in both compression and tensile strength. The reduction of concrete strength can be attributed to the high water-cement ration and absence of celeca compound in paper sludge, which is essential of bonding and structure of cement concrete.

3. "Worked on mechanical properties of papercrete by taking various samples and experimenting on them". (2007).by.H.Yun et al.

Which includes 5% paper-cement replacement ratio was 34 MPa and water-binder ratio hardly affected compressive strength of papercrete. According to paper replacement ratio, compressive strength affected rapidly. According to them, the density of papercrete was decreased when the replacement ratio of waste paper of papercrete increased. The splitting tensile strength also decreased by including higher replacement ratio of waste paper.

4. "Conducted an experimental study which investigated the potential use of paper waste for producing a low-cost and light-weight composite brick". (2011).by, Malthy and Jegatheeswaran.

They investigated three different mix proportions of fly-ash-mixed papercrete blocks with and without sand. In all three bricks, the compressive strength was more than the required, i.e., 3.5 MPa. The bricks have water absorption more than 20%. Papercrete blocks did not burn with an open flame. They smoldered like

charcoal but if the interior plaster and exterior stucco is provided on the bricks, the bricks would not burn at all. The results showed that the effect of high-level replacement of paper wastes does not exhibit sudden brittle fracture and it reduces unite weight and introduce smooth surface as compare to current conventional bricks.

5. "Development and study of some properties of Papercrete concrete". (2014).By, M. Rame Gowda, K. Prasanna.

Carried an experimental work on Papercrete concrete cubes made with cement, sand, paper and fly ash in different mix proportions for determine the some properties. They had reported as Papercrete can easily be molded into any desired shape, light in weight compared to conventional blocks and very good surface finish can be achieved.

3.MATERIALS

3.1 MATERIAL USED

Detail of material and test procedures used for testing regime is given below,

3.1.1 Cement:-

A 53grade cement Pozzolona Portland cement confirming to IS 1489 (paer 1): 1991 was used for concrete cube manufacturing. Cement was not older than 40days at the time of testing as well as concrete casting.

3.1.2 Fine aggregate:-

Locally available natural river sand passing through 4.75 mm IS sieve was used as fine aggregate along with artificial sand and waste foundry sand which were used as partial blending materials.

3.1.3 Coarse aggregate:-

Paper stone 20 mm aggregate having maximum angular shaped store fragments for concrete manufacturing, were used for the experimental testing work.

3.1.4 Water:-

Potable water available at concrete technology lab at NMCE , Peth. Was used for manufacturing as well as testing purpose.

3.1.5 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.

3.2 EXPERIMENTAL WORK

An experimental work was conducted to get the specific gravity, water absorption and grading of course aggregate, fine aggregate, crush sand. This data required to design a concrete mix.

3.2.1 TESTS ON COURSE AGGREGATE

3.2.1.1 Specific Gravity and Water Absorption Test

Apparatus

(a) A balance of capacity about 3kg, to weigh accurate 0.5g, and of such a type and shape as to permit weighing of the sample container when suspended in water. (b) A thermostatically controlled oven to maintain temperature at 100-110° C. (c) A wire basket of not more than 6.3 mm mesh or a perforated container of convenient size with thin wire hangers for suspending it from the balance. (d) A container for filling water and suspending the basket (e) An air tight container of capacity similar to that of the basket (f) A shallow tray and two absorbent clothes, each not less than 75x45cm.

Observation:-

Weight of saturated aggregate suspended in water with basket = W1 g = 2700 g

Weight of basket suspended in water = W_2 =1000 g

Weight of saturated aggregate in water = $W_1 – W_2$ = 1700 g

Weight of saturated surface dry aggregate in air = W_3 = 2690 g

Weight of oven dry aggregate = W_4 = 2660 g

CALCULATIONS:

(1) Specific gravity = $W_3 / \{W_3 – (W_1 – W_2)\}$

G =2690/ {2690 – (2700 -1000)}

G = 2.7

(2) Water Absorption = $\{(W_3 – W4_4) / W_4\}$ X 100

= {(2690-2660) /2660} X 100

= 1.123%

Result:-

(1) Specific gravity = 2.7(2) Water Absorption = 1.123 %

3.2.2 TESTS ON FINE AGGREGATE

3.2.2.1 Specific Gravity and Water Absorption Test

Apparatus: - Pycnometer, Fine aggregate, Measuring cylinder, Well Ventilated Oven, Taping rod.

Observation:-

1. Mass of Pycnometer (M_1) = 680 gm.
2. Mass of Pycnometer + Fine aggregate (M_2) = 980 gm.
3. Mass of Pycnometer + Fine aggregate + Water (M_3) =1740 gm.
4. Mass of Pycnometer + Water (M_4) = 1550 gm.
5. Weight of oven dry aggregate in air = 333 gm.

Calculation:-

I) Specific gravity (G) = $(M_2-M_1)/ ((M_2-M_1)-(M_3-M_4))$

Specific gravity (G) = (980-680)/ ((980-680)-(1740-1550))

=2.5

II) Water absorption = ((350-333)/333) X100

=5.48%

Result:-

i) The Specific Gravity of a given sample of fine aggregate is found to be 2.5

ii) The Water Absorption of a given sample of fine aggregate is found to be 5.48 %

3.2.2.2 Silt content test

Test procedure of silt content in sand.

The permissible Silt content in sand percentage is only 6%.

Result: -

Sr.No.	Items	Sample
1	Volume of sample V_1 ml.	500 ml.
2	Volume of silt after 3 hr ,V_2 ml.	20ml.
3	Percentage silt by volume = V_2/V_1 x 100	4%

Table 3.1: sieve analysis for fine aggregate

3.2.2.3 SIEVE ANALYSIS

There is standard specification for Fine aggregates (Sand). It is divided in four gradations. Generally known as Zone I, Zone II, Zone III and Zone IV. There is sieve Designation for each grade. Gradation is made as per the use of the sand. There are testing sieves for testing the sand. A set of Sieves with square hole is available.

Total weight of sample:-1000gm

Result: - Grading zone of fine aggregate ZONE I.

3.2.3 Test on cement

3.2.3.1. Procedure of Fineness Test on Cement

Fineness Test on Cement is carried out to check proper grinding of cement. Fineness of cement particles may be determined either by sieve test or by permeability apparatus test.

In sieve test, the cement weighing 100 gm is taken and it is continuously passed for 15 minutes through standard BIS sieve no. 9. The residue is then weighed and this weight should not be more than 10 per cent of original weight.

In permeability apparatus test, specific surface area of cement particles is calculated. This test is better than sieve test and it gives an idea of uniformity of fineness. The specific surface acts as a measure of the frequency of particles of age size. The specific surface of cement should not be less than 2250 cm2/gm.

Result -

Sr.No.	Description	Result
1	Weight of cement (w)gm.	100gm.
2	Weight of cement retained after sieving through 90 micron (w1)gm.	4.9gm.
3	Percentage weight of retained on the sieve w1/w X 100	4.9%

Table 3.2: Fineness Test on Cement

3.2.3.2 Procedure of Standard consistency test:

Result:-

Sr.No.	Observation	1	2	3	4
1	Weight of water added(W2)gm.	81.05	97.5	104	110.5
2	Penetration of plunger from bottom in mm.	25	27	30	33
3	% water by weight = W2/W1 X 100	25%	30%	32%	34%

Table 3.3: Standard consistency test

3.2.3.3 Initial and final setting time:

Result:-

Time at witch water is first added to cement (T1) = 3.40 PM.

Time when initial setting time needle reaches for penetration up to 33 to 35 mm from top of mould (T2) = 4.20 PM.

Time when final setting time needle makes an impression but the attachment fails to do so (T3) = 7.40 PM.

Sr. no.	Description	calculation	Result
1	Initial setting time	T2-T1 = 40 min	Not less than 30 min
2	Final setting time	T3-T1 = 240 min	Not greater than 600 min.

Table 3.4: Standard consistency test

3.2.4 Test on paper

Properties

1. Weight => 40.5 gm.
2. Thickness => 0.005 mm.
3. Moisture => 7.5 %.

4.DESIGN OF M30 GRADE CONCRETE

In this concrete mix design M30 was designed based on IS: 10262-1982, IS: 456-2000. This code presents a generally applicable method for selecting mixture proportion for high strength concrete and optimizing this mixture proportion on basis of trial batches.

4.1 DESIGN PROCEDURE:-

Procedure for concrete mix design requires following step by step process

1. Calculation of target strength of concrete.
2. Selection of water-cement ratio.
3. Determination of aggregate air content.

4. Selection of water content for concrete.
5. Selection of cement content for concrete.
6. Calculation of aggregate ratio.
7. Calculation of aggregate content for concrete.
8. Trial mixes for testing concrete mix design strength.

4.2 DATA FOR MIX PROPORTIONING:

- Characteristic strength in 28 days :- 30MPa
- Type of cement:- OPC53 Grade
- Workability:- Medium(100mm slump)
- Maximum nominal size of aggregate:- 20mm
- Specific gravity:

i) Fine aggregate: - 2.5

ii) Coarse aggregate: - 2.7

iii) Cement: - 2.85

- Water absorption (%):

i) Fine aggregate: - 5.48

ii) Coarse aggregate: - 1.123

- Grading zone :

i) Fine aggregate: - I

A) Target Mean Strength

Characteristic strength F_{ck} =30

$F_{ck} = F_{ck} + 1.65X\ s$

$= 30+8.25$

$F_{ck} = 38.25$ N/mm

Where s is the standard deviation taken as 5N/mm

B) Water/ Cement Ratio

It depends on i) exposure condition ii) maximum nominal size of aggregate iii) type of concrete.

W/C ratio mentioned in table 5 of IS 456 is 0.45. W/C adopted ratio is 0.42. This is lesser than 0.45.

C) Selection of Water Content

i) Maximum nominal size of aggregate = 20mm

ii) Workability of concrete is medium therefore slump is 75mm.

Required water content is increased by 3% for every 25mm increased slump.

Required water content = 186+ (3/100) x186= 191.5 liters

D) Calculation of Cement Content

W/C Ratio = 0.42

Water used =191.5 liters

Cement content = w/c

= 197/0.42

= 456kg/m^3

Check for minimum cement content given in is 456 table no 5 is 340 kg/cum less than 456 kg/cum. Hence OK

E) Calculation of Coarse and Fine Aggregate Content

Volume of coarse aggregate corresponding to 20mm nominal size of aggregate and fine aggregate zone -I . For water- cement ratio of 0.42 = 0.6

a) Correction in water cement ratio:

Water cement ratio lowered by 0.01. The coarse aggregate is increased at the rate of 0.06

Therefore volume of coarse aggregate wate cement ratio 0.42 is 0.606

i) Corrected proportion volume of coarse aggregate is for w/c ratio of 0.42

= 0.606 x 1

= 0.606

ii) Proportion of volume of fine aggregate = 1- 0.606 = 0.394

F) Calculation of Mix Proportion

The mix proportion per unit volume of concrete

a) Volume of concrete = 1 cum

b) Volume of cement = (mass of cement)/ (mass density of cement)

= (456)/ (2.857x1000)

= 0.160 cum

c) Volume of water = (mass of water)/(mass density of water)

= (195.5)/ (1x1000)

= 0.192 cum

d) Volume of Aggregate = 1-(0.160+0.192)

= 0.648 cum

e) Mass of coarse aggregate = (volume of aggregate) X (Proportion volume of coarse aggregate)X(Mass density of coarse aggregate)

= 0.648 x 0.606 x (2.75x1000)

= 1080 kg/m^3

f) Mass of fine aggregate = (volume of aggregate) X (Proportion volume of fine aggregate) X (Mass density of fine aggregate)

=0.648x0.394 x (2.5x1000)

=638.28 kg/m^3

G) Mix Proportion for One cum Concrete

Cement = 1.53 kg

Water = 0.8

Fine Aggregate = 2.039 kg

Coarse Aggregate = 3.6045 kg

C: FA: CA = 1: 1.32: 2.34

H) Field Correction

Absorption of fine aggregate = 5.48%

= 1/100(638)

= 35 kg/m^3

Absorption of coarse aggregate = 1.123 %

= 1.123/100(1080)

= 12 kg/m^3

With regard to water = 35+12=47 kg/m^3

Absorption by fine and coarse aggregate so this much water added total water

= 191.5 + 47

= 238.5 kg/m^3

Proportion of material

Cement = 456 kg

Water = 238.5 liters

Fine Aggregate = 603 kg

Coarse Aggregate = 1038 kg

C: FA: CA =1: 1.32:2.34

I) Final mix proportion:-From all above adjustments the mix proportions is

Cement (Kg/m^3)	Water (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)
456	238.5	603	1068
1	0.52	1.23	2.34

Table no 4.1 final mix proportions

4.3 FINAL MIX PROPORTIONS FOR REPLACEMENT OF NATURAL SAND BY PAPER

The following tables give the detailed information about the ingredients required for the% replacement of natural sand by paper.

4.2 Mix Proportion For 0% Replacement of cement by paper

Cement (Kg/m^3)	Water (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)
456	238.5	603	1068
1	0.52	1.23	2.34

Table no 4.2:- Mix proportion for 0% replacement

4.3 Material Required For Casting of 3 Cubes For 0 % Replacement of cement by Paper

Sr.No	Material	Weight(gm)
1	Cement	4.6
2	Fine Aggregate	6.117
3	Paper	0
4	Course Aggregate	10.81
5	Water	2.4

Table no 4.3:- material required for casting of cubes by weight for 0% Replacement

4.4 Mix Proportion For 5% Replacement of cement by paper

Cement + Paper(Kg/m^3)	Water (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate(Kg/m^3)
432.2+22.8	238.5	603	1068
1	0.40	1.21	2.26

Table no 4.4:- Mix proportion for 5% replacement

4.5 Material Required For Casting of 3 Cubes For 5 % Replacement of cement by paper

Sr.No	Material	Weight (gm's)
1	Cement	4387
2	Fine Aggregate	6117
3	Paper	230
4	Course Aggregate	10812
5	Water	2400

Table no 4.5:- Material Required For Casting of 3 Cubes For 5 % Replacement of cement by paper

4.6 Mix Proportion For 10% Replacement of cement by paper

Cement + Paper (Kg/M3)	Water(Kg/M3)	Fine Aggregate(Kg/M3)	Course Aggregate(Kg/M3)
410.4+45.6	238.5	603	1068
1	0.52	1.23	2.34

Table no 4.6:- Mix proportion for 10% replacement

4.6 Material Required For Casting of 3 Cubes For 10 % Replacement of cement by paper

Sr.No	Material	Weight(gm)
1	Cement	1385
2	Fine Aggregate	6117
3	Paper	153.9
4	Course aggregate	1081.35
5	water	2400

Table no 4.6:- Material required for casting of cubes by weight for 10% replacement

4.4TRIAL MIXES FOR TESTING CONCRETE MIX DESIGN STRENGTH

Based on the values obtained above, conduct a trail test by making at least 3 cubes of 150mm size as per the standards. Test of that cubes verify S the required strength is gained.

Sr.No	Cube No	Compressive Strength N/mm^2	Avg.Strength N/mm^2
1	C1	25	26.5
2	C2	27	
3	C3	27.5	

Table no: - 4.7 Results of trial mix cubes

Result of trial mix cubes:-Compressive strength = 26.5 N/mm^2

5. MAKING OF PAPER PULP

1. Newspapers are ripped up into small pieces in a container and it is covered with boiling water.

2. Leave to soak for 3 days until the paper has turned mushy.

3 A stucco mixer newspaper with water Paper isn't pulping into small Pieces, extra water is added to make it easier.

4. It is then mixed with cement, sand into a more uniform and consistent mass with the help of electric mixer. The mixer was allowed to work for around 34 minutes to obtain paper Crete.

7. RESULT AND DISCUSSION

9.1 COMPRESSIVE STRENGTH

The concrete cubes are casted with replacement of natural sand by 0%, 5%, 10% paper. The corresponding compressive strengths of 7 days with replacement of cement by paper and exposure are shown in tables.

9.1.1 Compressive strength for7 days with replacement of paper.

The following table gives the compressive strength in N/mm^2 for 7 days with replacement of sand by various % of

Sir no.	% Replacement of cement by paper	Compressive strength in N/mm^2			Average Compressive strength in N/mm^2
1	0%	17.5	18	19.5	18.33
2	5%	17	16.5	18	17.17
3	10%	16	17	16.5	16.5

Table 9.1:– compressive strength for 7 days with replacement of paper.

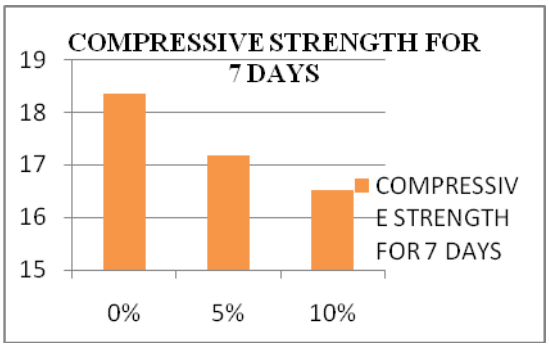


Fig 9.1:– compressive strength for 7 days with replacement of paper

9.2.2Compressive strength for 28 days with replacement of PAPER BY CEMENT.

Concrete cubes are casted with replacement of natural sand by 0%, 5%, 10% paper sand. The corresponding compressive strengths of 28 days with replacement of cement by paper and exposure are shown in tables. The following table gives the compressive strength in N/mm^2 for 28 days with replacement of natural sand by various % of paper.

Sr no.	Percentage Replacement of paper by cement	Compressive strength in N/mm^2			Average Compressive strength in N/mm^2
1	0%	34.1	32.22	32.44	32.92
2	5%	30.2	31.5	31.2	30.96
3	10%	30.5	29.7	29	29.73

Table 9.2 – compressive strength for 28 days with replacement of paper.

9.2 HEATING TEST

9.2.1 Weight comparison between normal block and paper Crete block

Before heating test

Normal Cube(Kg)	Paper Crete Cube 5% (kg)	Paper Crete Cube 10%(Kg)
8.480	8.420	8.410

After heating test

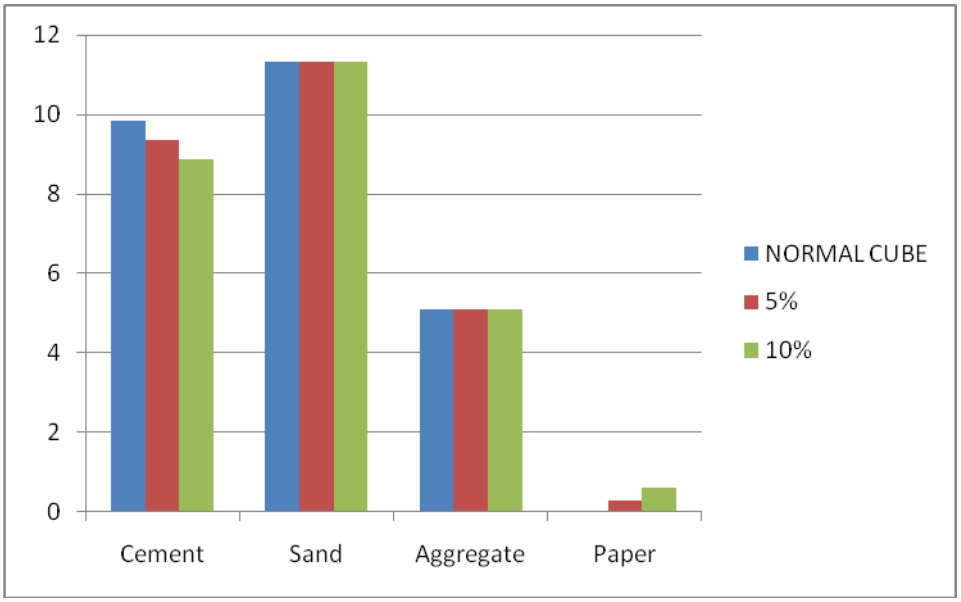
Normal Cube (Kg)	Paper Crete Cube 5% (Kg)	Paper Crete Cube 10% (Kg)
8.340	8.330	8.290

9.2.2 Compressive strength after fire test.

Normal Cube (N/mm^2)	Paper Crete Cube 5% (N/mm^2)	Paper Crete Cube 10% (N/mm^2)
21.11	20.85	20.20

10.ECONOMY CHART

Material	One cube Normal concrete(rupees)	5% paper use concrete	10% paper use concrete
Cement	9.85	9.35	8.88
Sand	11.31	11.31	11.31
Aggregate	5.11	5.11	5.11
Paper	0	0.3	0.6



10. CONCLUSION

- For 5% and 10% replacement of cement by paper it is clearly seen that compressive strength are nearly equal to normal concrete after curing of 7 days and 28 days.
- After heating test for 100^0 c for 5% and 10% replacement of cement by paper compressive strength of papercrete concrete cubes are nearly equal to normal concrete cubes.
- After heating test for 100^0 c for 5% and 10% replacement of cement by paper weight of 5% replaced papercrete concrete cube remains same but in 10% replaced papercrete concrete cube weight is reduced.

11. FUTURE SCOPE

- For 15 % replacement of cement by paper it is seen that compressive strength are will be equal to normal concrete hence we conclude that in future we can replace cement by 15 % paper in concert.
- The structural behavior of reinforced papercrete structure member like beam, slab, etc., needs to be investigated in depth.

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