EXPERIMENTAL STUDIES ON PARTIAL REPLACEMENT OF CEMENT WITH CHALK POWDER AND COCONUT FIBER ASH

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Abstract: *The cost of constructing a building is increasing day by day as cost of building materials are increasing, the use of any alternative material that has tendency to partially replace the building material may reduce the cost of the construction to certain level. In this research we have selected two materials Chalk Powder and Coconut Fiber Ash for partially replacement with cement. Both the materials are easily available, renewable and also cheap. The grade of concrete on which the investigation will be performed will be M40 grade. The main aim of this research is to check if the two above materials can be used instead of cement up to certain percentage. In this project, the workability, compressive strength as well as flexural strength of conventional concrete (CC), concrete made of Chalk Powder (CP), concrete made of Coconut Fiber Ash (CFA), and concrete made from mixture of both materials has been studied. The compressive and the flexural strength was calculated at 3 days, 7 days and 28 days of normal curing. The percentage replacement for the cement used is 5%. 10% and 15% by weight of cement. For calculating the compressive strength, cubes of size 150 x 150 x 150 mm were casted and were tested using Compression Testing Machine. In this project the distribution of cubes casted are – 12 are CC, 12 are CP (5%), 12 are CP (10%). 12 are CP (15%), 12 are CFA (5%), 12 are CFA (10%), 12 are CFA (15%), 12 are CP + CFA (5%), 12 are CP + CFA (10%) and 12 for CP + CFA (15%). For calculating the flexural strength, beam of size 500 x 100 x 100 mm were casted and were tested under Flexural Testing Machine under two point loading effect. The distribution of beams casted are – 9 are CC, 9 are CP (5%), 9 are CP (10%), 9 are CP (15%), 9 are CFA (5%), 9 are CFA (10%), 9 are CFA (15%), 9 are CP + CFA (5%), 9 are CP + CFA (10%) and 9 are of CP + CFA (15%).*

Keywords: concrete, CP – chalk powder, CFA – coconut fiber ash, M40, workability, compressive strength, flexural strength

I. INTRODUCTION.

A building material, concrete is an integration of cement, fine and coarse aggregates with water, which on hardening produces solid stone mass. The strength of this solid mass can be enhanced by adding some admixtures during mixing of the ingredients. In simple words concrete production can be defined as the procedure of combining together the various constituents like water, cement, aggregates to produce concrete.

A. Benefits of Chalk Powder

- Chalk Powder can be used for finishing, decorating works in construction phase.
- Chalk Powder is less reactive and is taken as a base.
- Chalk Powder is used as an anti-slipping material, it is used in gyms, on heads of screwdriver.
- Eco-Friendly material, available in abundant quantities.
- Jewellery rubbed with chalk Powder are resistant from getting tarnished.

B. Benefits of Coconut Fiber Ash

- Coconut Fiber Ash is a decomposable material that deteriorates slowly and has a life span up to 4 years.
- Coconut Fiber Ash is an inexhaustible resource.
- Coconut Fiber does not diminish, break or generates crust.
- Coconut Fiber is nature friendly.
- The pH value of Coconut Fiber lies between 6 – 6.7.

Fig 1: Chalk Powder and Coconut Fiber Ash

II. NOMINAL MIX DESIGN.

❖ ***Target mean strength of concrete***
For a tolerance factor of 1.65 and using table 1 from IS 10262-2000, the standard deviation S = 5 N/mm^2. So, Target mean strength can be given by, Characteristic cure strength = 40 + (5x1.65) = 48.25 N/mm^2.

❖ ***Selection of water cement ratio***

From table 5 from IS 456-2000, maximum water cement ratio = 0.4, adopt water cement ratio as 0.40

0.40 < 0.45 Hence ok.

❖ ***Selection of water cement content***

From table-2 of I.S 10262-2009, maximum water content is 180 liter (for 75-100mm) slump range for 20mm aggregate. Estimate water content for (75-100mm) slump = 180 kg/m3, required water content = 180 + 5.4 = 185.4 kg/m^3

❖ ***Calculation of cement content***

Cement $= \left[\frac{185.4}{0.40}\right] = 463.5$ kg/m^3

❖ **Mix calculation**

The calculations per unit volume of concrete shall be as follows;

a) Volume of concrete = 1 m^3

b) Volume of cement $= \left[\frac{mass\ of\ cement}{specific\ gravity\ of\ cement}\right] \times \left[\frac{1}{1000}\right]$

$= \left[\frac{463.5}{3.15}\right] \times \left[\frac{1}{1000}\right] = 0.147$ m^3

c) Volume of water $= \left[\frac{mass\ of\ water}{specific\ gravity\ of\ water}\right] \times \left[\frac{1}{1000}\right]$

$= \left[\frac{185.4}{1000}\right] = 0.185$ m^3

d) Volume of all in aggregate $= [a - [b + c + d]]$
= 1- [0.147 + 0.185]= 0.502 m^3

e) Volume of coarse aggregate = 0.502 x 2.60 x 1x 1000 = 1153.13 Kg/m^3

f) Mass of fine aggregate = 0.197 x 2.60 x1 x 1000 = 512.2 kg/m^3

Table 1: Mix Design Proportion for M-40 Conventional Concrete.

	Cement	Fine aggregate	Coarse aggregate	Water
Weight (kg/m^3)	463.5	512.2	1153.13	185.4 liter
Mix Ratio	1	1.11	2.49	0.40

❖ **Conventional Concrete (CC) -** Size of the cube used for compression test is as per the IS standard, 150mm x 150mm x 150mm

We require, Cement = 0.15 x 0.15 x 0.15 x 463.5 = 1.56 kg, Fine aggregate = 0.15 x 0.15 x 0.15 x 512.2 = 1.72 kg

Coarse Aggregate = 0.15 x 0.15 x 0.15 x 1153.13 = 3.90 kg, Water = 0.15 x 0.15 x 0.15 x 185.4 = 0.62 l

Table 2: Mix Design Proportions for 12 CC cube of Size 150 x 150 x 150 mm

W/C ratio	Cement	Fine Aggregate	Coarse Aggregate	Water
0.40	18.72 kg	20.64 kg	46.80 kg	7.44 l

For flexural text beam casted are of IS standard size 500 x 100 x 100 mm. The quantity of materials used for casting beams are given as:

Cement = 0.10 x 0.10 x 0.50 x 463.5 = 2.31 kg, Fine aggregate = 0.10 x 0.10 x 0.50 x 512.2 = 2.56 kg,

Coarse aggregate = 0.10 x 0.10 x 0.50 x 1153.13 = 5.77 kg, Water = 0.10 x 0.10 x 0.50 x 185.4 = 0.93 l

Table 3: Mix Design Proportions for 9 CC beam of Size 500 x 100 x 100 mm

W/C ratio	Cement	Fine Aggregate	Coarse Aggregate	Water
0.40	20.80 kg	23.04 kg	51.93 kg	8.37 l

A. *Replacement of Cement with Chalk Powder.*

Table 4: Mix Design Proportions for 12 concrete cubes containing replacement of cement with chalk powder

Replacement %	Cement	Fine Aggregate	Coarse Aggregate	Chalk Powder	Water
5%	17.79 kg	20.64 kg	46.80 kg	0.93 kg	7.44 l
10%	16.85 kg	20.64 kg	46.80 kg	1.87 kg	7.44 l
15%	15.92 kg	20.64 kg	46.80 kg	2.80 kg	7.44 l

Table 5: Mix Design Proportions for 9 concrete beams containing replacement of cement with chalk powder

Replacement %	Cement	Fine Aggregate	Coarse Aggregate	Chalk Powder	Water
5%	19.76 kg	23.04 kg	51.93 kg	1.04 kg	8.37
10%	18.72 kg	23.04 kg	51.93 kg	2.08 kg	8.37
15%	17.68 kg	23.04 kg	51.93 kg	3.12 kg	8.37

B. *Replacement of Cement with Coconut Fiber Ash.*

Table 6: Mix Design Proportions for 12 concrete cubes containing replacement of cement with CFA

Replacement %	Cement	Fine Aggregate	Coarse Aggregate	CFA	Water
5%	17.79 kg	20.64 kg	46.80 kg	0.93 kg	7.44 l
10%	16.85 kg	20.64 kg	46.80 kg	1.87 kg	7.44 l
15%	15.92 kg	20.64 kg	46.80 kg	2.80 kg	7.44 l

Table 7: Mix Design Proportions for 9 concrete beams containing replacement of cement with CFA

Replacement %	Cement	Fine Aggregate	Coarse Aggregate	Chalk Powder	Water
5%	19.76 kg	23.04 kg	51.93 kg	1.04 kg	8.38
10%	18.72 kg	23.04 kg	51.93 kg	2.09 kg	8.37
15%	17.68 kg	23.04 kg	51.93 kg	3.12 kg	8.37

C. Replacement of Cement with mixture of Chalk Powder and Coconut Fiber Ash.

Table 8: Mix Design Proportions for 12 concrete cubes containing replacement of cement with CP and CFA

Replacement %	Cement	Fine Aggregate	Coarse Aggregate	CP	CFA	Water
5%	17.79 kg	20.64 kg	46.80 kg	0.465 kg	0.465 kg	7.44 l
10%	16.85 kg	20.64 kg	46.80 kg	0.935 kg	0.935 kg	7.44 l
15%	15.92 kg	20.64 kg	46.80 kg	1.40 kg	1.40 kg	7.44 l

Table 9: Mix Design Proportions for 9 concrete beams containing replacement of cement with CP and CFA

Replacement %	Cement	Fine Aggregate	Coarse Aggregate	CP	CFA	Water
5%	19.76 kg	23.04 kg	51.93 kg	0.52 kg	0.52 kg	8.37
10%	18.72 kg	23.04 kg	51.93 kg	1.04 kg	1.04 kg	8.37
15%	17.68 kg	23.04 kg	51.93 kg	1.56 kg	1.56 kg	8.37

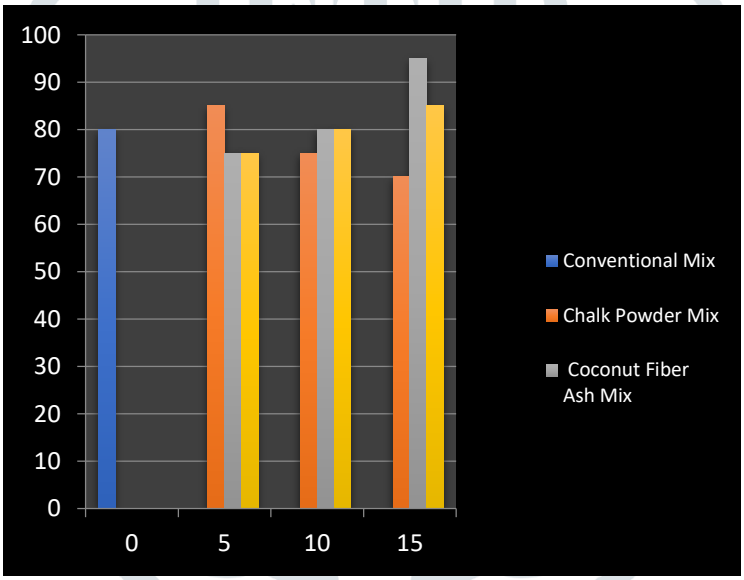
Fig 2: Cubes and Beams before testing.

III. RESULTS:

A. Slump Test.

Table 10: Slump Values Obtained.

Replacement %	Slump Value CP (mm)	Slump Value CFA (mm)	Slump Value CP + CFA (mm)
0	80	80	80
5	85	75	75
10	75	80	80
15	70	95	85



Graph 1: Slump value obtained

B. Compressive Strength Values.

Table 11: Average Compressive Strength (N/mm^2) for cubes of Conventional Concrete

3 Days	7 Days	28 Days
20.6	32.53	47.69

Table 12: Average Compressive Strength (N/mm^2) for cubes of concrete containing 5% replacement.

Replacement	3 Days	7 Days	28 Days
Chalk Powder	21.73	33.29	53.11
Coconut Fiber Ash	20.99	32.23	51.03
CP + CFA	22.00	33.79	54.95

Replacement	3 Days	7 Days	28 Days
Chalk Powder	22.93	35.40	57.24
Coconut Fiber Ash	19.73	30.59	45.14

CP + CFA	22.43	34.27	56.04

Table 13: Average Compressive Strength (N/mm^2) for cubes of concrete containing 10% replacement

Table 14: Average Compressive Strength (N/mm^2) for cubes of concrete containing 15% replacement

Replacement	3 Days	7 Days	28 Days
Chalk Powder	20.18	30.87	42.00
Coconut Fiber Ash	18.62	28.37	39.30
CP + CFA	18.96	28.92	41.07

C. *Flexural Strength Values.*

Table 15: Average Flexural Strength (N/mm^2) for beams of Conventional Concrete

3 Days	7 Days	28 Days
3.17	3.90	6.93

Table 16: Average Flexural Strength (N/mm^2) for beams of concrete containing 5% replacement.

Replacement	3 Days	7 Days	28 Days
Chalk Powder	3.27	4.00	7.83
Coconut Fiber Ash	3.26	3.92	7.78
CP + CFA	3.26	4.08	7.98

Table 17: Average Flexural Strength (N/mm^2) for beams of concrete containing 10% replacement

Replacement	3 Days	7 Days	28 Days
Chalk Powder	3.44	4.16	8.16
Coconut Fiber Ash	3.14	3.81	6.61
CP + CFA	3.37	4.02	7.84

Table 18: Average Flexural Strength (N/mm^2) for beams of concrete containing 15% replacement

Replacement	3 Days	7 Days	28 Days
Chalk Powder	3.20	3.87	6.36
Coconut Fiber Ash	3.01	3.69	6.42
CP + CFA	3.08	3.74	6.71

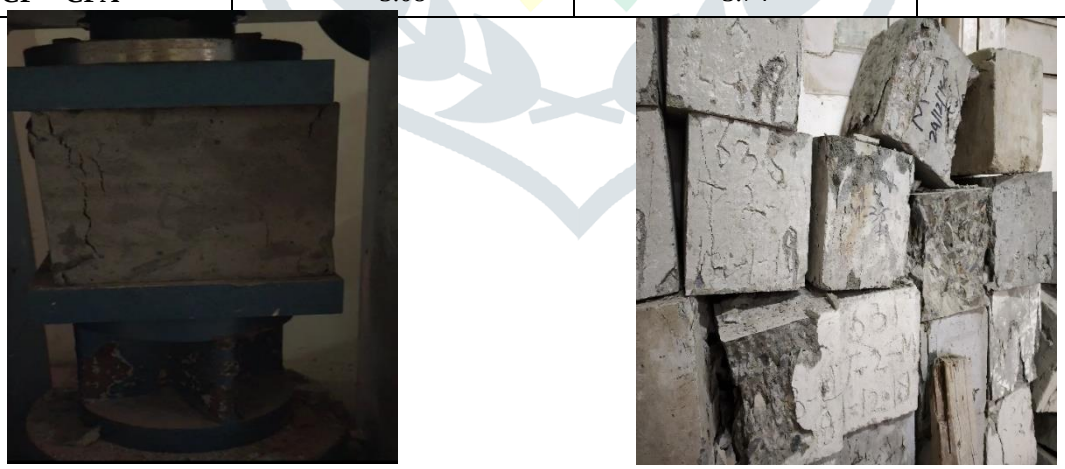
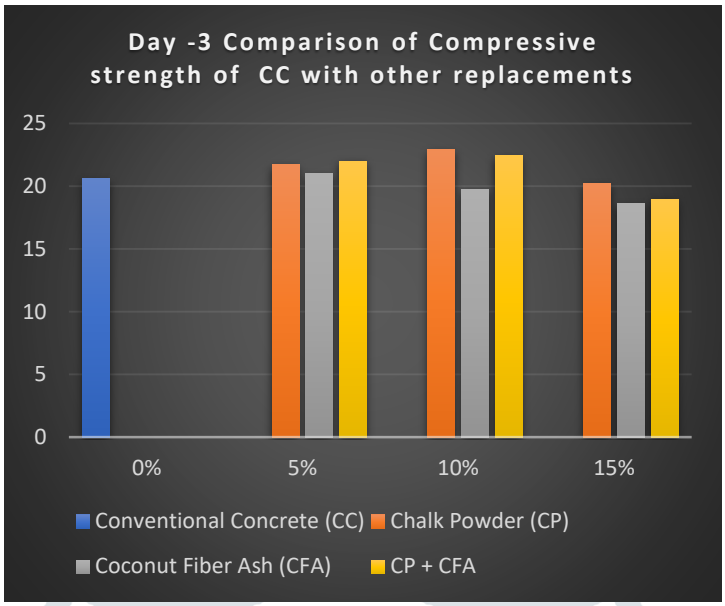


Fig. 3: Cube in Compression Testing Machine and cubes after testing.

IV. DISCUSSIONS

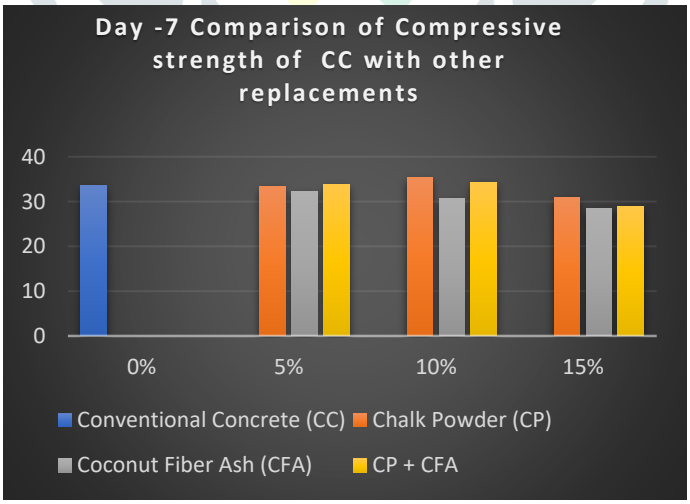
A. *Comparison of Compressive Strength for Day 3 of Conventional Concrete with concrete containing replacements for cement.*



Graph 2: Compressive Strength Day 3 of CC with concrete containing replacements for cement.

The above graph shows the comparison between the compressive strength of conventional concrete with other replacement materials of cement. The compressive strength of the conventional concrete after 3 days curing is 20.60 N/mm^2. On comparing it with chalk powder we are observing that there is an increment of 5.49% and 11.31% with respect to CC when cement was replaced by 5% and 10% respectively. On further increasing the CP content to 15%, we observed that there is a decrement of 1.94%. When CFA was used as a replacement materials it was found that increment of 1.90% for 5% replacement, after increasing the content the compressive strength starts to decrease in percentile of 4.22% and 9.61% for 10% and 15% respectively when compared with the CC. When the mixture of CP and CFA was used it has been observed that the strength gets increased in percentage of 6.80%, 8.88% for 5% and 10% replacement respectively and decrement of 7.96% for replacement with 15% was noticed.

B. Comparison of Compressive Strength for Day 7 of Conventional Concrete with concrete containing replacements for cement.

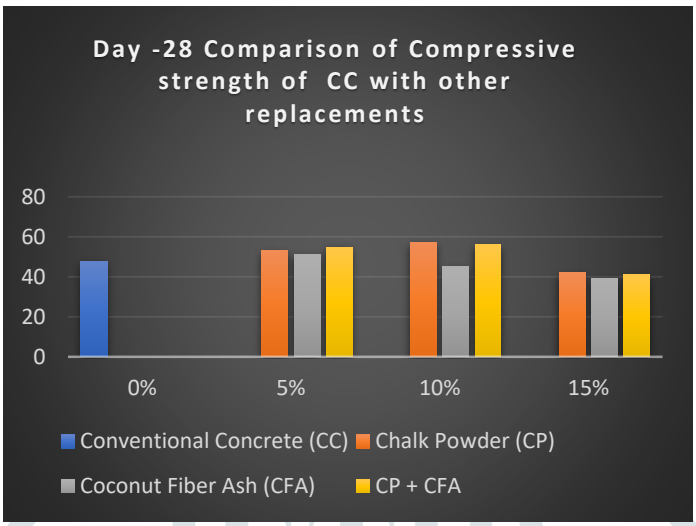


Graph 3: Compressive Strength Day 7 of CC with concrete containing replacements for cement.

The above graph represents Day 7 compressive strength comparison of CC with other replacement materials. The compressive strength of the CC after 7 days curing is 32.53 N/mm^2. When compared with chalk powder it has been found that there is an increment of 2.33% and 8.82% with respect to CC when cement was replaced by 5% and 10% respectively. On further increasing the CP content to 15%, it was found that there is a decrement of 5.10%. When CFA was taken as a replacement materials it was noticed the strength remained approximately same as that of CC for 5% replacement, after increasing the content the compressive strength starts to decrease in percentile of 5.96% and 12.78% for 10% and 15% respectively when compared with the CC. When

CP and CFA was mixed and then used it has been observed that the strength gets increased in percentage of 3.87%, 5.34% for 5% and 10% replacement respectively and decrement of 11.09% for replacement with 15% when compared to CC.

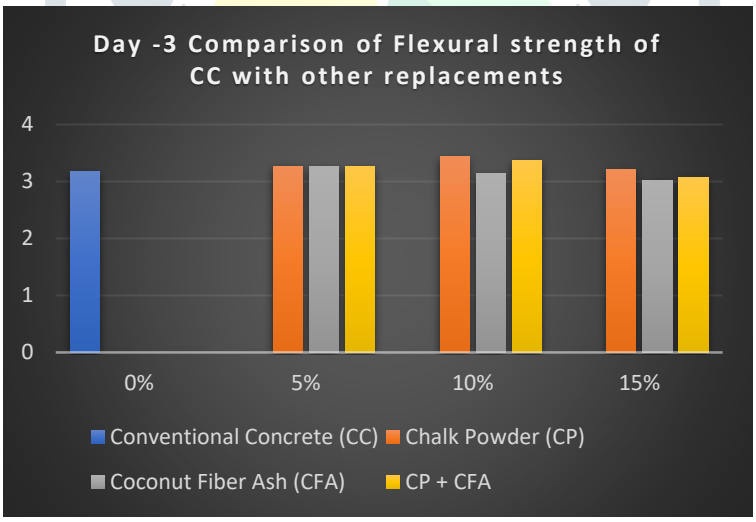
C. ***Comparison of Compressive Strength for Day 28 of Conventional Concrete with concrete containing replacements for cement.***



Graph 4: Compressive Strength Day 28 of CC with concrete containing replacements for cement.

The above graph represents Day 28 compressive strength comparison of CC with other replacement materials. The compressive strength of the CC after 28 days curing is 47.69 N/mm^2. If we compare it with chalk powder we noticed that there is an increment of 11.36% and 20.02% for 5% and 10% replacement respectively. For 15% replacement, it has been observed that there is a decrement of 11.93%. When CFA was taken as a replacement materials it was noticed there was an increment of 7% for 5% replacement, and decrement of 5.34% and 17.59% for 10% and 15% respectively. After combination of both the replacement materials the compressive strength increased in percentage of 15.22%, 17.50% for 5% and 10% replacement respectively and decrement of 13.88% for replacement with 15% when compared to CC.

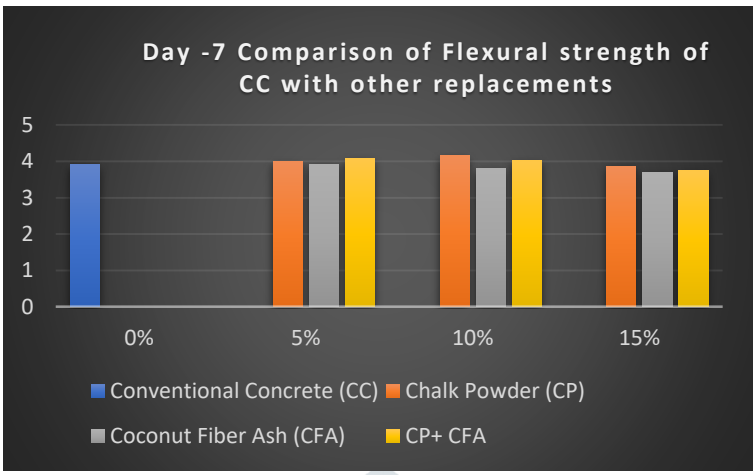
D. Comparison of Flexural Strength for Day 3 of Conventional Concrete with concrete containing replacements for cement.



Graph 5: Flexural Strength Day 3 of CC with concrete containing replacements for cement.

The above graph indicates the comparison made between the flexural strength of conventional concrete with concrete made up of adding replacing materials. The flexural strength of the conventional concrete obtained after 3 days curing is 3.17 N/mm^2. When compared it with chalk powder we observed that there is an increment of 3.15% and 8.51% when cement was replaced by 5% and 10% respectively. On further increasing the CP content to 15%, we observed that the flexural strength remained almost same as that of the conventional concrete. When CFA was used as a replacement materials it was found that increment of 2.84% for 5% replacement, after increasing the content the flexural strength starts to decrease in percentile of 0.95% and 5.04% for 10% and 15% respectively when compared with the CC. When the mixture of CP and CFA was used it has been observed that the strength increased in percentage of 2.83%, 6.30% for 5% and 10% replacement respectively and decrement of 2.83% for replacement with 15%.

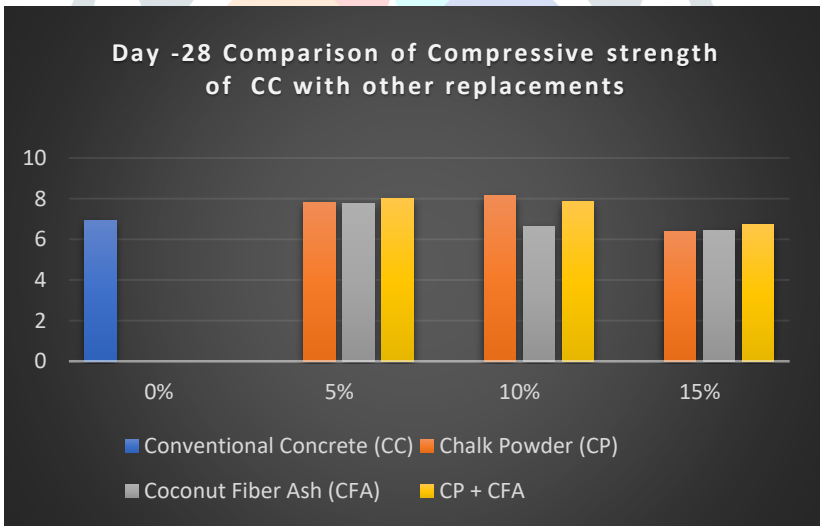
E. Comparison of Flexural Strength for Day 7 of Conventional Concrete with concrete containing replacements for cement.



Graph 6: Flexural Strength Day 7 of CC with concrete containing replacements for cement.

The above graph represents Day 7 flexural strength comparison of CC with concrete containing replacement materials. The flexural strength of the CC after 7 days curing is 3.90 N/mm^2. When compared with chalk powder we observed that there is an increment of 2.56% and 6.67% with respect to CC when cement was replaced by 5% and 10% respectively. On further increasing the CP content to 15%, it was found that the strength was almost equal to that of conventional concrete. When CFA was taken as a replacement materials it was observed the strength remained approximately same as that of CC for 5% replacement, after increasing the content the flexural strength starts to decrease in percentile of 2.56% and 5.38% for 10% and 15% respectively when compared with the CC. When CP and CFA was mixed and then used it has been observed that the strength gets increased in percentage of 4.61%, 3.07% for 5% and 10% replacement respectively and decrement of 4.10% for replacement with 15% when compared to CC.

F. Comparison of Flexural Strength for Day 28 of Conventional Concrete with concrete containing replacements for cement.



Graph 7: Flexural Strength Day 28 of CC with concrete containing replacements for cement.

The above graph represents Day 28 flexural strength comparison of CC with other replacement materials. The flexural strength of the CC calculated after 28 days curing is 6.93 N/mm^2. If we compare it with chalk powder we noticed that there is an increment of 12.98% and 17.75% for 5% and 10% replacement respectively. For 15% replacement, it has been observed that there is a decrement of 8.22%. When CFA was taken as a replacement materials it was noticed there was an increment of 12.26% for 5% replacement, and decrement of 4.62% and 7.35% for 10% and 15% respectively. After combination of both the replacement materials the flexural strength increased in percentage of 15.15%, 13.13% for 5% and 10% replacement respectively and decrement of 3.17% for replacement with 15% when compared to CC.

V. CONCLUSION

The use of Chalk Powder and Coconut Fiber Ash as partial replacement of Cement should be taken up for acceptable and environmental friendly construction. By using these easily available and the agricultural waste material in construction, we can decrease the cost of construction up to certain level and overcoming the environmental hazards. This investigation has also

demonstrated that the use of chalk powder and coconut fiber ash by certain percentage can produce positive results when partially replaced by cement. Thus can be used in construction purpose. It is observed that by replacement the cement with Chalk Powder up to 10% by weight of cement, the compressive as well as flexural strength for the M40 grade concrete gets enhanced. In case of Coconut Fiber Ash the strength properties examined gets improved when the replacement is up to 5%, after increasing the content of CFA, the strength starts to decrease and when the mixture of both the replacement materials was used and replaced with the cement, the strengths got intensify up to 10% and on further adding decrement of strengths was noticed.

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