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An Experimental Study of Partial Replacement of Cement by Eggshell Powder and Corncob ASH in Concrete

G.Divya[1], V.S.Suswara[1], S.Reshmitha[1], A.Vaishaki[1], G.Shankar[1], K.Lokesh Varma[1], Dr.S.Shameem Banu[2]

[1]B.Tech Student, Department of Civil Engineering, University College of Engineering Kakinada, Andhra Pradesh

[2] Faculty of Civil Engineering Department, University College of Engineering Kakinada

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Abstract:

Utilizing unused materials would reduce the need for cement and lower the cost of production while lowering the cost of construction materials in developing nations. Cement, fine aggregate, coarse aggregate, and water are the main ingredients of concrete. Here, replacement materials like corn cob ash and powdered egg shells made from poultry waste are used. Cement partially replaces these materials. These materials that have been replaced are handled sustainably. The eggshell powder has a high calcium content, while corn cob ash costs little and can be utilized to build any kind of building. In place of cement, eggshell powder and corn cob ash are employed partly in the amounts of 2.5%, 5.0%, 7.5%, and 10%. Concrete prisms, cubes,and cylinders were cast before being cured for 7,14, 28 days. It was tested for compressive strength, split tensile strength, flexural strength, and durability after a 28-day curing time. It was concluded that the CCA and ESP can be used as partial replacement of cement in concrete production as well as for walls of buildings units and other mild construction works, and replacement of CCA should not exceed 7.5% and ESP should not exceed 10% as strength produced above this replacement level may not be adequate for strength requirements.

Keywords —Cement, Corncob ash, Eggshell Powder

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I. INTRODUCTION

The most common building material and the second most consumed well worldwide, after water, is cement. The most expensive component in the manufacturing of concrete is cement; therefore,even a small per-unit cost decrease will have a significant impact on the overall cost of the project. The world's carbon dioxide emissions are largely related to the cement industry, which produces more cement every year. Because of cement's considerable contribution to environmental pollution, the high cost of Portland cement, and the heavy consumption of natural resources like limestone, etc., we cannot continue producing it at an exponential rate.

We are attempting to substitute the cement in concrete in this case with corn cob ash (CCA) and poultry waste Egg Shell Powder to lower the cost of producing concrete by using agricultural waste, which is scientifically referred to as pozzolans (ESP).

Silicate Hydrate (CSH), these additional cementitious materials improve concrete quality while also lowering the cost of producing concrete. After rice and wheat, maize is the third-most significant food crop in India. It is mostly grown in 8.7 million ha (2019) during the Kharif season, which accounts for 80% of the total area. At current pricing, maize contributes almost 9% of the country's food supply and more than $100 billion to the agricultural GDP in India, in addition to providing over 100 million man-days of work in the agricultural and downstream industrial sectors. If widely adopted, using corncob ash in concrete with normal strength will revolutionize the building industry through cost-saving measures. It is a new dimension of concrete agitation design.

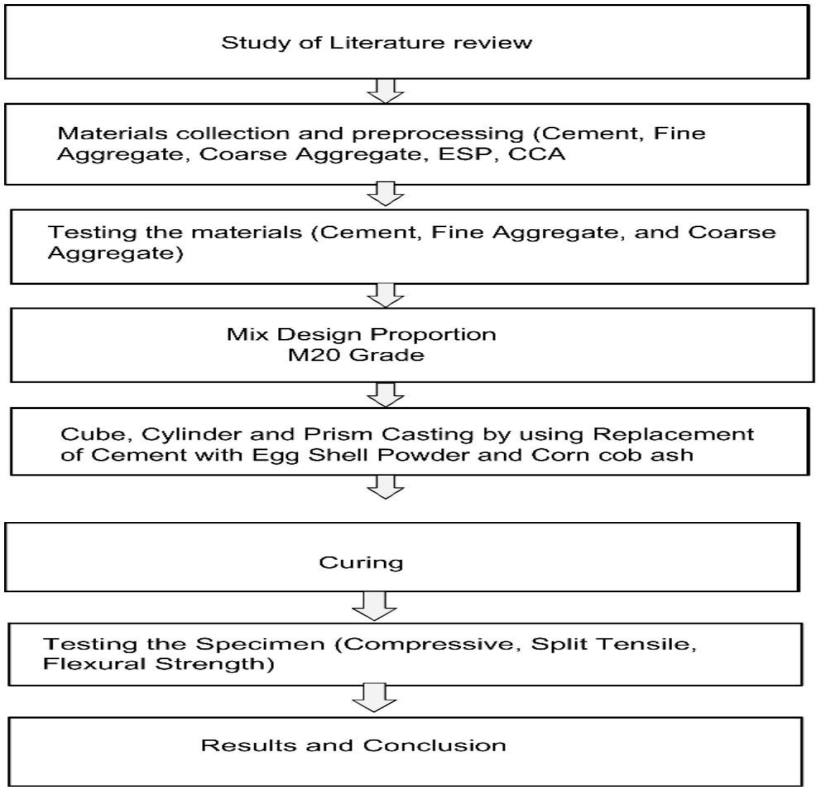
II. LITERATURE REVIEW

Ally Manzoor Ahmad (2018) This research looks at how the stability of a structure is enhanced by the quality of the building materials used. An effort has been made to look into the potential applications of eggshell powder in paver blocks. By using the method of replacement by weight, the eggshell powder was used to replace cement in small amounts at intervals of 5% from 0% to 25%. The block of pavers Curing takes place for 7 and 28 days, following which the product is tested for both flexural and compressive strength. It was noted that a 10% replacement of eggshell powder resulted in a 13.4% improvement in compressive strength. Additionally, flexural strength increased by 19.5% at the same 10% Eggshell Powder replacement.

By experimentally replacing cement in concrete mixtures with CCA at 0%, 5%, 10%, 15%, and 20% steps instead of cement, Kamau and Ahmed (2017) evaluated the suitability of CCA as a partial replacement for cement. The strongest compressive strength was noted at the 7.5% replacement levels, which also demonstrated excellent strengths suited for structural tasks, according to the researchers who used the sulfate elongation test to test durability. Additionally, they noticed that all CCA specimens performed well in the sulfate elongation test when compared to the control mix. The researchers concluded that the results were highly reproducible and highlighted the potential of CCA as a potent pozzolan.

The advantages of switching from Ordinary Portland Cement (OPC) to CCA mixed cement were assessed by Antonio et al. in 2014. They experimented to determine the proper % substitution of CCA that would adhere to the necessary cement manufacturing criteria. Compressive strength, workability, and thermal performance of various CCA mixed cement were all to be examined in the experimental plan. The researchers concluded that adding CCA to the mixtures could increase the compressive strength and workability of the resultant concrete by up to 10% while not compromising the structural integrity of OPC. Also, they noted that the addition of 10% CCA can significantly reduce the mixture's thermal conductivity.

III. METHODOLOGY



MATERIALS

Eggshell powder, corn cob ash, fine aggregate, water, ordinary Portland cement 53 grade, andcoarse aggregate were the components used for this project.

CHEMICAL COMPOSITION:

The following chemical parameters are examined to confirm the acceptability of corn cob ash(CCA) and eggshell powder as a partial replacement for cement:

Chemical composition	**Cement**	**CCA**	**ESP**
Silicon dioxide(SiO_2)	20.32	62.30	0.08
Aluminum oxide(Al_2O_3)	4.80	6.45	0.03
Ferric oxide(Fe_2O_3)	2.80	4.38	0.02
Calcium oxide(CaO)	61.9	10.57	52.1
Magnesium oxide(MgO)	2.60	1.68	0.01
Sodium oxide(Na_2O)	0.16	0.34	0.15
Potassium oxide(K_2O)	0.85	3.91	-
Sulphur Trioxide(SO_3)	3.7	1.04	0.57
Loss on ignition(LOI)	1.9	-	47.8

PROPERTIES OF MATERIALS:

a) **CEMENT** : (Ordinary Portland Cement 53 grade)

S.NO	PHYSICAL PROPERTY	EXPERIMENTAL RESULTS
1	Fineness of cement	5%
2	Specific gravity	3.15
3	Normal Consistency	32%
4	Initial Setting Time	92 min
5	Final Setting Time	210 min

b) FINE AGGREGATE:

The particles that pass through a 4.75mm sieve but remain on a 0.075mm sieve are known as fine aggregates. 2.4 is the specific gravity. 2.6 is the fineness modulus. The partly compact bulk density is 1461 kg/m^3. 1635 kg/m^3 is the bulk density (completely compressed).

c) EGG SHELL POWDER:

Calcium carbonate and other chemical components make up eggshell powder. The most affordable and accessible waste product is this one. ESP has a specific gravity of 2.37.

Fig:1 Eggshell powder

d) CORNCOB ASH:

The specific gravity of CCA is 2.55. Corn Cob ash is obtained by burning corn cob waste. CCA isabout 70 % of the combined content of SiO_2 and CaO.

Fig:2 Corn Cob Ash

MIX PROPORTION:

The standard method of expressing the proportions of ingredients of a concrete mix is in terms ofparts or ratios of cement, fine aggregates, and coarse aggregates.IS Method used for mix designand finally for M20 grade of concrete. The mix is 1:1.83:3.32.

Cement	Fine aggregate	Coarse aggregate	Water
1	1.83	3.32	0.5

MIXING OF MATERIALS:

Material blending is necessary for the creation of consistent specimens. The mass should become homogeneous, uniform in color, and consistent as a result of the mixing. Eggshell powder replacement for cement is 2.5%, 5%, 7.5%, and 10%, while corn cob ash replacement is 2.5%, 5%, 7.5%, and 10%, and both are blended at 5%, 10%, and 15%.

CASTING AND CURING:

After the mixing, the concrete is taken in a testing process and immediately fill the cube mold, cylinder mold, and prism mold and compacting the concrete thoroughly either by vibrator or by hand. Any air in the concrete will reduce the strength of the specimen.to compact the concrete may cause segregation of the aggregates and cement paste in the mix. The size of the cube is 150mmx150mmx150mm, the size of the cylinder is 300mm in height, 150mm in diameter, and the size of the prism is 150x150x750mm.

Casting

After remolding the specimens, the specimens (cube, cylinders, and prism) are kept in water for curing to promote the hardening of concrete by proper curing, the durability of
concrete is increased and shrinkage is reduced.

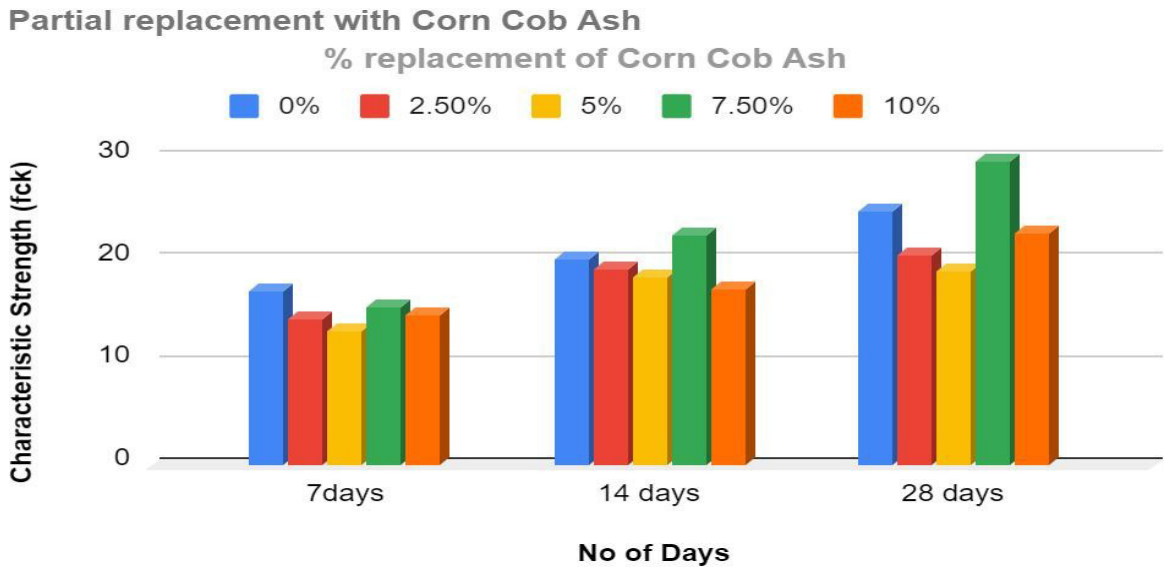
LABORATORY RESULTS:

COMPRESSIVE TEST STRENGTH:
The most often used test for concrete cubes is the compressive test. The cube is 150mmx150mmx150mm in dimension. The cube specimen was evaluated after seven andfourteen days of curing. The specimens were put in the compression testing device, and the

pressure that causes a certain concrete sample to fail was applied. The compressive strength has been tested for cement substitution with eggshell powder and coconut shell ash at 5%, 10%,and 15%.

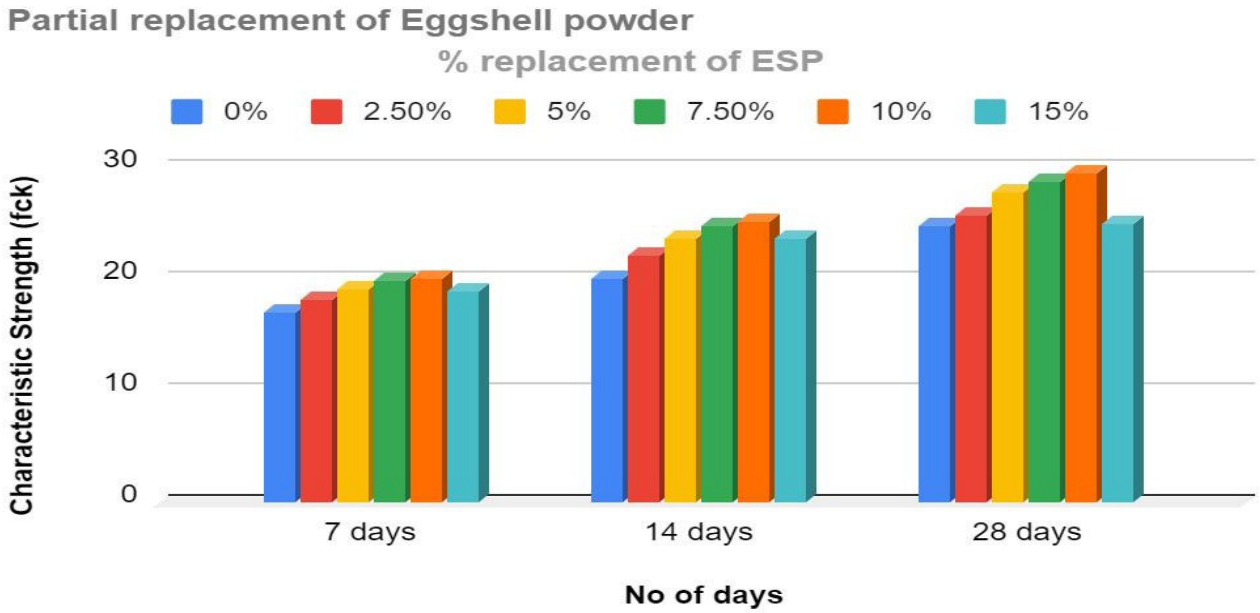
Compressive strength = (P/A) in N/mm^2

a)



S.no	% replacement	7days (N/mm^2)	% Variation w.r.t control	14 days (N/mm^2)	% Variation w.r.t control	28 days (N/mm^2)	% Variation w.r.t control	Average %variation
1	0%	17.05	-	20.07	-	24.85	-	-
2	2.5	14.39	-15.6	19.22	-4.2	20.60	-17.1	-12.3
3	5	13.11	-23.1	18.35	-8.5	19.05	-23.3	-18.3
4	7.5	15.47	-9.2	22.45	+11.8	29.65	+19.3	+7.3
5	10	14.67	-13.9	17.28	-13.9	22.68	-8.73	-12.17

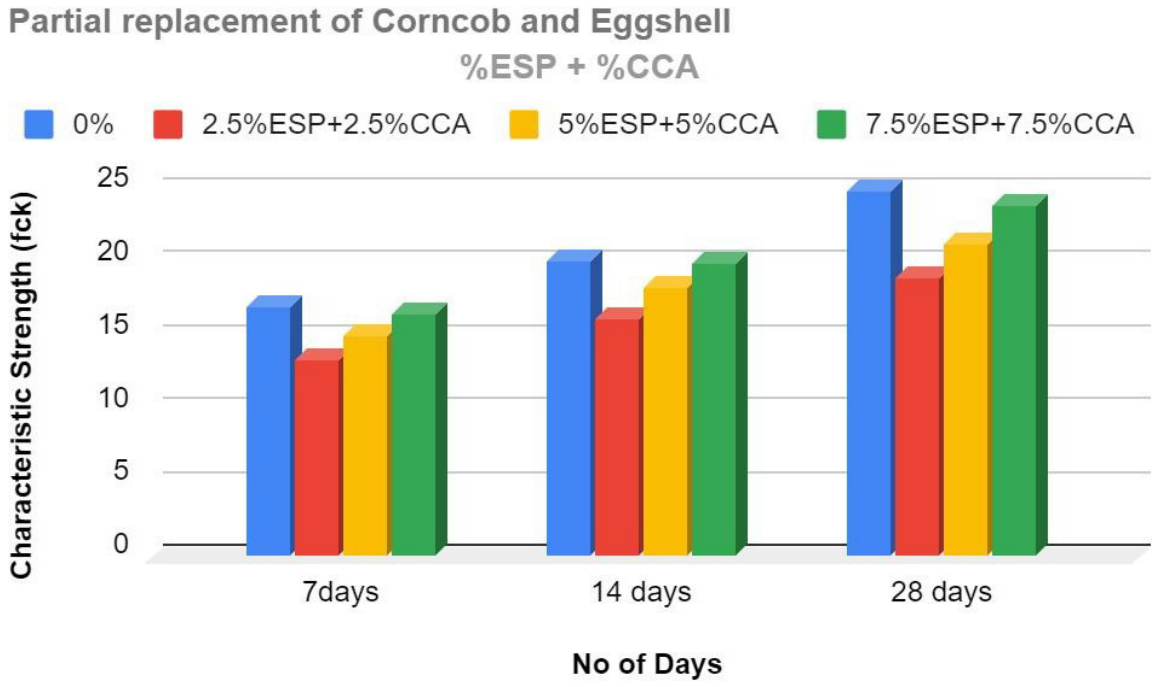
b)



S.no	% replacement	7days (N/mm^2)	% Variation w.r.t control	14 days (N/mm^2)	% Variation w.r.t control	28 days (N/mm^2)	% Variation w.r.t control	Average %variation
1	0	17.05	-	20.07	-	24.87	-	-
2	2.5	18.1	6.15	22.1	10.11	25.61	2.9	6.38
3	5	19.06	11.7	23.66	17.88	27.86	12.02	13.8
4	7.5	19.8	16.12	24.7	23.06	28.72	15.48	18.22
5	10	20.08	17.77	25.1	25.06	29.4	18.2	20.33
6	15	15.65	-8.21	18.54	-7.62	22.63	-9.00	-8.28

c) Partial replacement of Corncob and Eggshell:

S.no	%ESP + %CCA	7days (N/mm^2)	% Variation w.r.t control	14 days (N/mm^2)	% Variation w.r.t control	28 days (N/mm^2)	% Variation w.r.t control	Average %variation
1	0%	17.05	-	20.07	-	24.85	-	-
2	2.5%ESP+ 2.5%CCA	13.48	-20.9	16.28	-18.88	19.04	-23.3	-5.47
3	5.0%ESP+ 5.0%CCA	15.03	-11.84	18.34	-8.62	21.3	14.08	-2.12
4	7.5%ESP+ 7.5%CCA	16.52	-3.1	20.02	-0.24	23.93	-3.7	-2.34

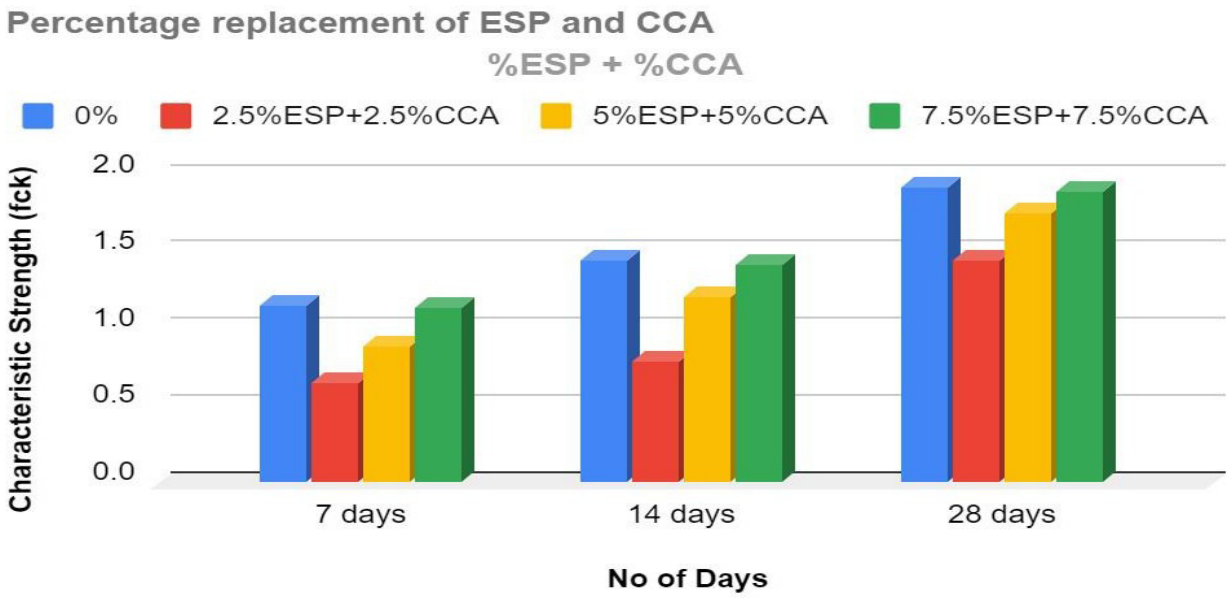


6. SPLIT TENSILE STRENGTH TEST:

Concrete's tensile strength can be assessed using the split tensile strength test. A compression testing machine is used to carry out the split tensile strength test. On a cylinder, a split tensile strength test was performed. The size of a cylinder is 300mm in height and 150mm in diameter. The specimen(cylinder) is cured and tested for 7 days,14 days, and 28 days in a compression testing machine.

Split tensile strength = $2P/\pi LD$ in N/mm^2

S.no	%ESP + %CCA	7days (N/mm^2)	% Variation w.r.t control	14days (N/mm^2)	% Variation w.r.t control	28 days N/mm^2	% Variation w.r.t control	Average %variation
1	0%	1.15	-	1.45	-	1.92	-	-
2	2.5%ESP+ 2.5%CCA	0.65	-43.4	0.78	-46.2	1.45	24.4	-21.7
3	5.0%ESP+ 5.0%CCA	0.89	-22.6	1.20	-17.2	1.75	8.85	-10.3
4	7.5%ESP+ 7.5%CCA	1.13	-1.7	1.42	2.06	1.89	1.56	1.2

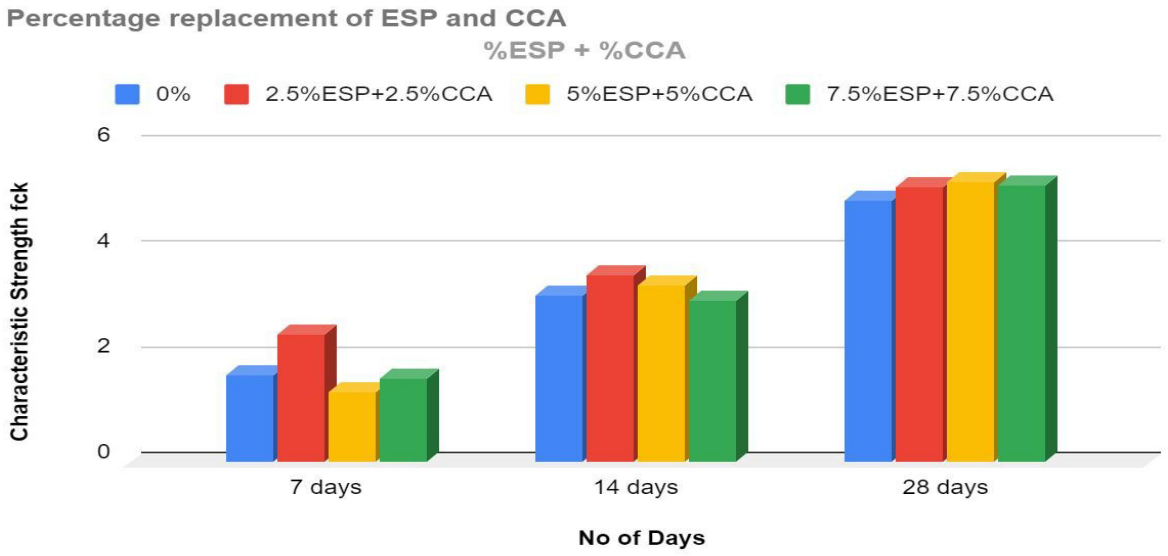


10. FLEXURAL STRENGTH TEST:

Concrete's tensile strength is evaluated indirectly by flexural strength. It evaluates a reinforced concrete beam and slab's resistance to bending failure. Flexural test results for concrete are represented by a rupture modulus, abbreviated as (M_R) in MPa or psi.

Flexural strength test $F = PL/(bd^2)$ in N/mm^2

S..no	%ESP + %CCA	7days (N/mm^2)	% Variation w.r.t control	14 days (N/mm^2)	% Variation w.r.t control	28 days (N/mm^2)	% Variation w.r.t control	Average %variation
1	0%	1.65	-	3.15	-	4.95	-	-
2	2.5%ESP+ 2.5%CCA	2.42	46.6	3.53	12.06	5.20	5.05	21.2
3	5.0%ESP+ 5.0%CCA	1.34	-18.7	3.34	6.03	5.32	7.4	-1.75
4	7.5%ESP+ 7.5%CCA	1.60	-3.03	3.07	-2.5	5.25	6	0.15



CONCLUSIONS

Following are conclusions drawn on the basis of the results obtained from the experimental works:

1. This Experimental study is based on investigating the partial replacement of cement by using partial replacement materials, which are Egg shell powder (ESP) and Corncob ash(CCA) to reduce the production of the cement.
2. The highest compressive strength was observed at the 7.5% replacement of CCA while higher replacement levels also showed impressive strengths suitable for structural loads.
3. The highest compressive strength was observed at the 10% replacement of ESP. The use of eggshell powder as a partial replacement for cement improves compressive strength by stabilizing Ettringite and mono-carbonate.
4. Percentage of weight loss increases with an increase in the percentage of ESP when exposed to solutions of sulfates and chlorides.
5. Basedon the test results, it is recommended that 10% CCA is optimum for cement replacement because this reduces the concrete strength beyond the control.
6. The compressive strength value decreases and maintains the strength during the partial replacement of 15% of replacing materials.
7. Flexural strength of concrete gradually increases according to the period of curing.
8. This shows that the mechanical properties of concrete increase when the cement is partially replaced in concrete with replacing materials such as Egg shell powder and Corn cob ash.

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