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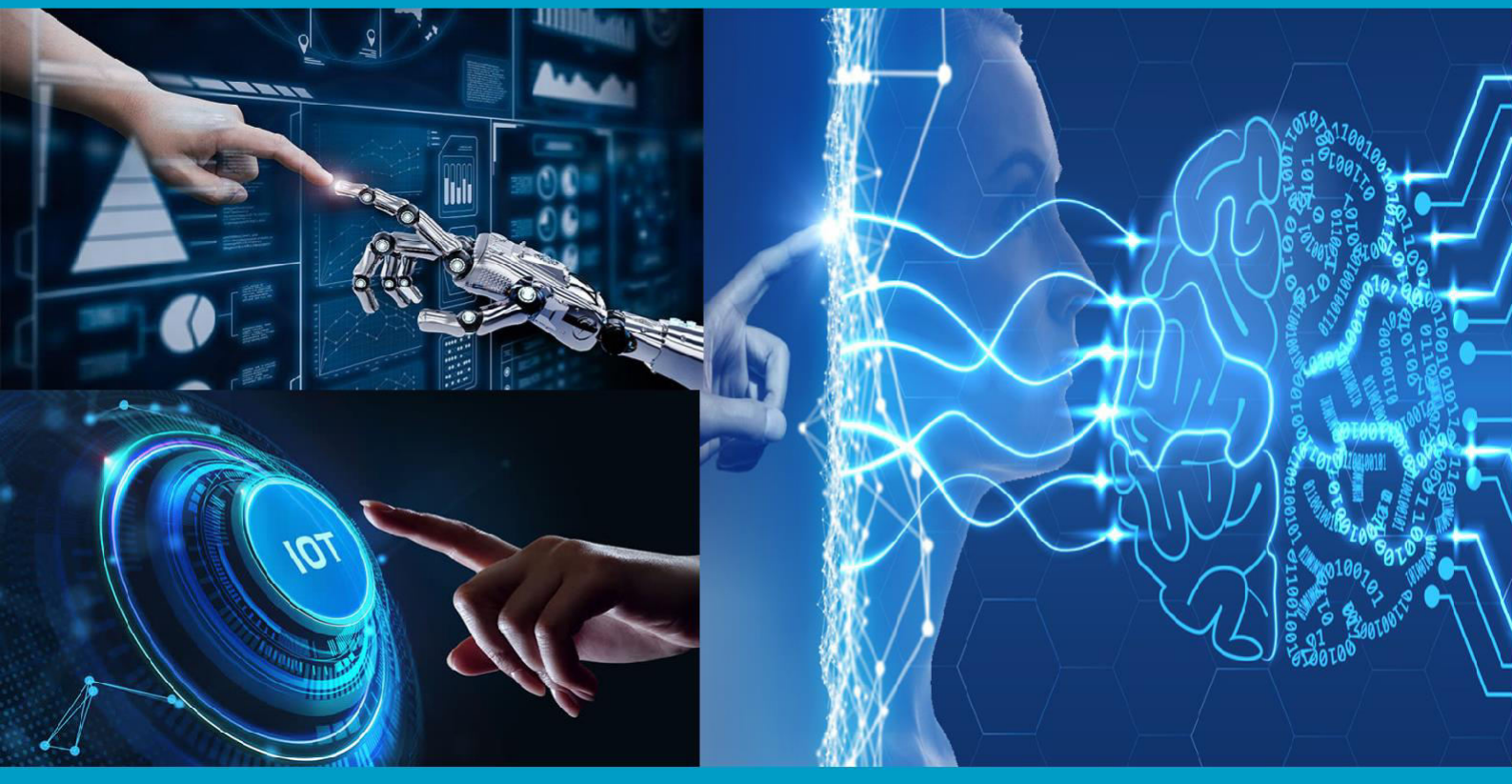

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Strength Evaluation of Fractional Replacement of Cement by Coconut Shell Ash and Egg Shell Powder

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ABSTRACT : The rising cost of construction materials in developing countries has necessitated research into the use of alternative pozzolanic materials in civil engineering construction. The use of certain component with potentially pozzolanic reactivity can significantly improve the properties of concrete. Egg Shell Powder (Calcareous Shell Powder) and Coconut Shell Ash is used as a substitute or mixture in cement. The characteristics of the coconut ash are dependent on the components like temperature and time of burning. It is burned under controlled temperature. In this research work, about three mixes of concrete are tried with fractional replacement of Egg Shell Powder and Coconut Shell Ash for ordinary Portland cement (OPC) i.e., 5%, 10%, 20% of partial replacement of cement in M20 grade concrete. It is then cured in water and is tested for its compressive strength on 3 days, 14 days and 28 days.

KEYWORDS: Cement, Concrete, Coconut shell ash, Egg shell powder, Admixtures.

I. INTRODUCTION

In construction sector there is always a demand to find a suitable material for effective replacement of cement since manufacturing of cement causes environmental pollution and lack of natural resources to a greater extent. Nowadays, all over the world aimed at increasing the reuse and recycling products, where it is technically, economically or environmentally acceptable. Coconut shells are cheap and readily available in high quantity. Coconut shell contains about 65-75% volatile matter and moisture which are removed largely during the carbonization process. The carbonization process converts coconut shells to charcoal by heating in the absence of oxygen. Egg shell consist of several growing layers of CaCo3 and it is a poultry waste with chemical composting nearly same as that of limestone. Use off egg shell waste to replace cement can have benefits like minimizing use of cement, conserves natural lime & utilizing waste materials, majority of egg shell wastes are deposited in landfill & it attracts vermin and causes human health & environmental problems. Numerous research works have been carried out to evaluate the performances of both the ashes as follows:

Praveen Kumar., (2006) experimentally investigated the partial replacement of cement with egg shell powder in M30 grade concrete and conducted the compressive strength test and split tensile strength test at 7 days and 28 days and also conducted flexural strength test at 28 days with the desired mixtures of egg shell powder and the results were compared with the controlled concrete specimens. Egg shell with silica fumes were used in special combos to discover the possibility of using the Egg shells as a trade to cement Egg shell powder replaces 10%, 20% and 30% further with the silica fume by using 5%, 10%, 15% of weight of cement. S. Karthikeyan., (2012) worked on reduction and reuse of the opportunity substances is a whole lot energetic to preserve their strength assets. The numerous proportions such as 2.5, 5 and 7.5% are tried on this research and the strength performed by way of ESP concrete is much higher than a nominal concrete. Every admixture has its own strength. There became a pointy decrease inside the power while the proportion of ESP is beyond the extent of 5%. La Taku., (2012) done experiments on agricultural waste material such as coconut shells and were collected and pulverized in the furnace from C to C for four hours to produce coconut shell ash (CSA), after XRF analysis was carried out to determine its

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pozzolanic property, which was used as partial replacement of cement in concrete production. Ranjith Kumar., (2017) found that Coconut Shell Ash and Eggshell Powder can be formed into useful binding materials. The properties of both wastes are within the range of the values of concrete making cement replacing material. The 10% replacement of cement by Coconut Shell Ash and Eggshell Powder has found to be attaining nearer strength as like conventional concrete

II. MATERIALS PROPERTIES

1.1. CEMENT, FINE AGGREGATE AND COARSE AGGREGATE

The Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete (Second Revision) for the preparation of concrete. The physical properties of cement, fine and coarse aggregates were found by conducting test in a laboratory environment and the values are given in Table 2.1. All the concreting work was carried out in a laboratory according to ISI0262:2009, The Indian Standard Concrete Mix Proportioning – Guidelines (First Revision). The concrete mix was designed for M20 grade and the procedure for casting of cubes and cylinders was done as per Indian Standards.

The mix proportions with the water-tocement ratio obtained for the M20 grade of concrete are given in Table 2.2.

Table 2.1 Material properties of cement, fine aggregate and coarse aggregate

Material Property	Cement	Fine aggregate	Coarse aggregate
Specific Gravity	3.15	2.66	2.74
Fineness Modulus	4%	2.30	6.32

Table 2.2 Mix proportions for M20 grade concrete

Water	Cement	Fine aggregate	Coarse aggregate
190	380	700	1170
0.5	1	1.84	3.07
Adopt Design Mix for M20 = 1:1.8:3			

1.2. EGG SHELL POWDER (ESP) AND COCONUT SHELL ASH (CSA)

Eggshell consists of several mutually growing layers of CaCO3, the innermost layer-maxillary 3 layer grows on the outermost egg membrane and creates the base on which palisade layer constitutes the thickest part of the eggshell. The top layer is a vertical layer covered by the organic cuticle. The eggshell primarily contains calcium, magnesium carbonate (lime) and protein. The quality of lime in eggshell waste is influenced greatly by the extent of exposure to sunlight, raw water and harsh weather conditions. It is the fine-grained powder with suitable proportion which is sieved to the required size before use with concrete/mortar. The image of Eggshell powder is shown in Fig.2.1. The specific gravity of ESP is 2.37.

Coconut shell ash is a light, black residue, consisting of carbon and any remaining ash, obtained by removing water and other volatile constituents from animal and vegetation substances. Charcoal is usually produced by slow pyrolysis, the heating of wood or other substances in the absence of oxygen (see char and biochar). It is usually an impure form of carbon as it contains ash; however, sugar charcoal is among the purest forms of carbon readily available, particularly if it is not made by heating but by a dehydration reaction with sulphuric acid to minimise the introduction of new impurities, as impurities can be removed from the sugar in advance. The resulting soft, brittle, lightweight, black, porous material resembles coal. The image of Eggshell powder is shown in Fig.2.2. The specific gravity of CSA is 2.15.

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Fig 2.1 Egg shell powder

Fig 2.2 Coconut Shell ash

1.2.1. CHEMICAL COMPOSITION OF EGG SHELL POWDER (ESP) AND COCONUT SHELL ASH (CSA)

Chemical composition of egg shell powder (ESP) and coconut shell ash (CSA) are shown in Table.2.3.

Table 2.2 Chemical composition of egg shell powder (ESP) and coconut shell ash (CSA)

Composition	Cement	ESP	CSA
Cao	63.8%	47.49%	9.39%
SiO_2	21.4%	0.11%	65.79%
Al_2O_3	5.1%	Nil	4.88%
Fe_2O_3	2.6%	Traces	2.01%
MgO	0.36%	Nil	3.92%
SO_3	3.38%	0.38%	0.98%
K_2O	1.88%	Nil	2.68%
Na_2O	0.14%	0.14%	0.07%

2. MATERIALS QUANTITY CALCULATION FOR CUBES AND CYLINDERS

The quantity of ingredients and admixtures used for fabrication of cubes and cylinders are shown in Table.3.1.

Table 3.1. Quantity of materials

Sample	Admixtures Composition	Materials	Cube (12 Nos)	Cylinder (4 Nos)
I	0% ESP and 0% CSA	Cement	4.62 kg	2.15 kg
		Fine aggregate	8.316 kg	3.87 kg
		Coarse aggregate	13.86 kg	6.45 kg
		Coconut Shell Ash	00	00
		Egg Shell Powder	00	00
		Water	2.31 l	1.075 l
II	5% ESP and CSA	Cement	4.389 kg	2.15 kg
		Fine aggregate	8.316 kg	3.87 kg

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		Coarse aggregate	13.86 kg	6.45 kg
		Coconut Shell Ash	115.5 g	53.75 g
		Egg Shell Powder	115.5 g	53.75 g
		Water	2.31 l	1.075 l
III	10% ESP and CSA	Cement	4.158 kg	2.15 kg
		Fine aggregate	8.316 kg	3.87 kg
		Coarse aggregate	13.86 kg	6.45 kg
		Coconut Shell Ash	231 g	107.5g
		Egg Shell Powder	231 g	107.5g
		Water	2.31 l	1.075 l
IV	20% ESP and CSA	Cement	3.696 kg	2.15 kg
		Fine aggregate	8.316 kg	3.87 kg
		Coarse aggregate	13.86 kg	6.45 kg
		Coconut Shell Ash	3.696 kg	215 g
		Egg Shell Powder	3.696 kg	215 g
		Water	2.31 l	1.075 l

IV. PREPARATION OF TEST SPECIMENS FOR TESTING

4.1. CASTING AND CURING OF CUBES AND CYLINDERS

Concrete cube of size 150x150x150 mm and cylinder of size 100mm diameter and 300mm height were cast and stored at room temperature and the specimens were demoulded after 24 hours and then kept for curing for 3 days, 14 days and 28 days. After reaching the required days of curing, the specimens were taken out from water curing tank and allowed to dry at room temperature before testing. 3 specimens were cast for each sample. Totally 36 concrete cubes and
12 cylinders were cast.

4.2. TESTING OF SPECIMENS

After the curing period, the specimens were subjected to compression test at 3, 14 and 28 days and split tension test.

4.2.1. COMPRESSION TEST

The cube (150x150x150mm) specimens were placed in compression testing machine and the load was applied without shock and increased continuously at a rate of approximately 140 kg/cm^2 per min until the resistance of the specimen to the increasing load breaks down and no greater load can be restrained.

4.2.2. SPLIT TENSION TEST

The splitting tests are well known as indirect tests used for determining the tensile strength of concrete. The load was increased until the specimen fails, and the maximum load applied to the specimen during the test was recorded. The mean value of the three specimen of each sample is taken as final split tensile strength value. Totally 36 concrete cubes and 12 cylinders were cast and conducted test for determining compressive strength at 3 days, 14 days and 28 days of curing and 12 cylinders were cast and split tension test were conducted at 28 days of curing.

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V. RESULTS AND DISCUSSION

The average value of compressive strength and split tensile strength of controlled concrete specimens (0% replacement level) and the specimens blended with Egg shell powder and coconut shell ash at different replacement level viz 5%, 10% and 20% with the quantity of cement are taken.

5.1. COMPRESSIVE STRENGTH

The graphical representation of variation of compressive strengths of concrete cubes at different replacement levels tested at 3 days, 14 days and 28 days are plotted in Fig.5.1. From the test results, it came to know that at 10% replacement level of ashes, the specimens withstand maximum compressive forces before failure at 3 days, 14 days and 28 days as compares with all other specimens viz 0%, 5% and 20% replacement level. The increase in strength at 10% replacement level is approximately 11.6%, 14% and 14% at 3days, 14 days and 28 days respectively as compared with 0% replacement level.

The fineness of ashes is more than the cement and hence the specific surface area is also increased. This property leads to enhance the strength of the specimens. But the increase in compressive strength is limited up to the replacement level of 10%.

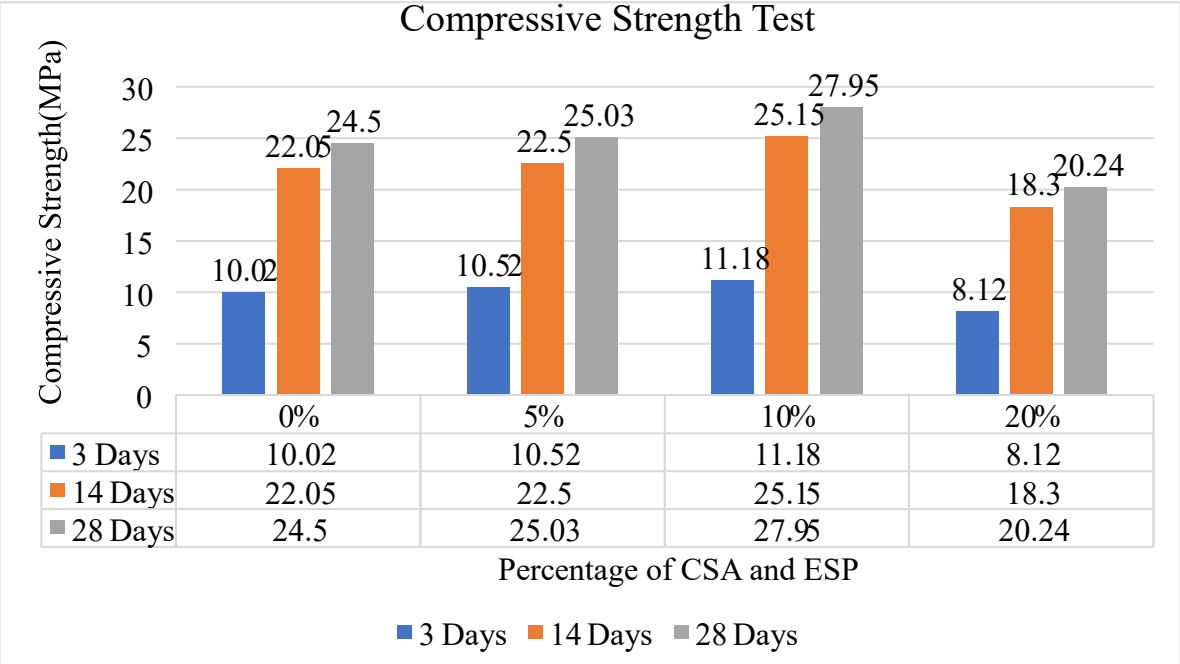

Fig.5.1. Compressive strength

5.2 SPILT TENSILE STRENGTH

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist, the direct tension because of its low tensile and brittle in nature. The determination of tensile strength of concrete in necessary to determine the load at which the concrete members crack. The cracking is a form a tensile failure. Tensile strength of concrete is much lower than its compressive strength and it has been estimated roughly 10% of compressive strength.

The controlled concrete specimens (0% replacement level) and the specimens blended with Egg shell powder and coconut shell ash at different replacement level viz 5%, 10% and 20% with the quantity of cement are

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tested at 28 days of curing period and the average value of tensile force of three specimens for each replacement level was taken for calculating the tensile strength.

The graphical representation of variation of tensile strengths of concrete cylinders at different replacement levels tested at 28 days are plotted in Fig.5.2. From the test results, it came to know that at 10% replacement level of ashes, the specimens withstand maximum tensile force as compares with all other specimens viz 0%, 5% and 20% replacement level. The increase in tensile strength of specimen at 10% replacement level is approximately 11.4% at 28 days as compared with 0% replacement level.

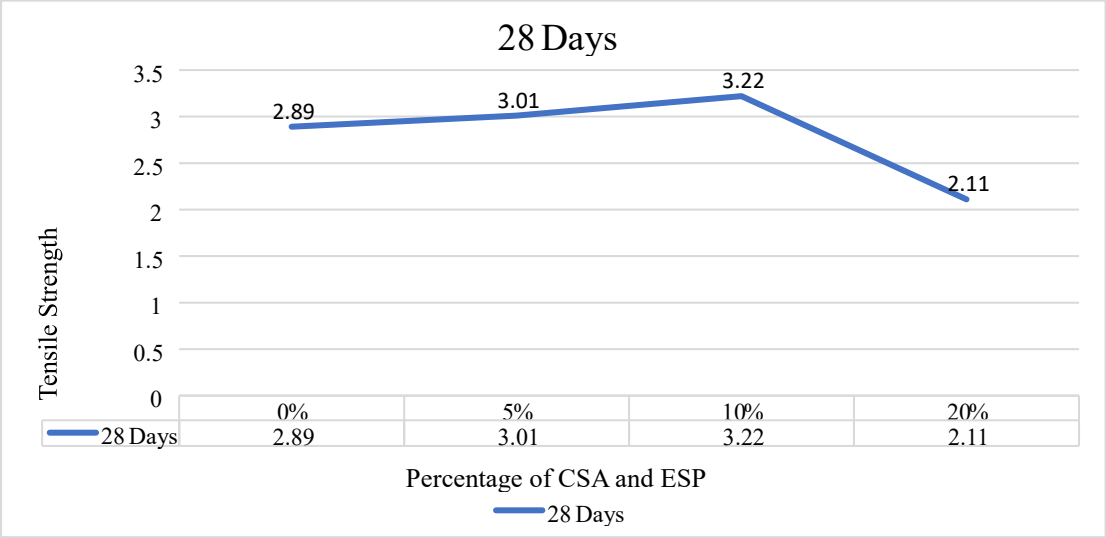

Fig 5.2 Split tensile strength

VI. CONCLUSION

The following points are concluded from the study on Coconut Shell Ash and Eggshell Powder as replacement for cement in concrete and they are applicable for the range of parameters and materials used in this study:

- Coconut Shell Ash and Eggshell Powder can be formed into useful binding materials. The properties of both wastes are within the range of the values of concrete making cement replacing material.
- From the experimental investigation, it has been found that the compressive strength and tensile strength of specimens mixed with ashes gradually increases with 5% and 10% replacement level.
- When the percentage of ESP and CSA was increased to 20%, the compressive strength and tensile strength results obtained is low that is it shows the decrease in the strength of concrete when compared to conventional concrete and hence advised not to be used.
- Hence, it is suggested that the Egg shell powder and Coconut shell ashes may be used up to 10% for replacement of cement.

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