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Experimental Study to Check the Effect of Egg Shell Powder and Rice Husk Ash on the Property of Concrete

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Abstract—Nowadays the conventional concrete construction industry is not sustainable due to huge consumption of natural materials and environmental pollution created during its production. The use of waste products as a cementitious material in concrete will reduce the use of cement and ultimately the construction cost. In the present investigation Rice Husk Ash and Egg Shell Powder are used as a replacement of cement. The compressive strength, spit tensile strength and flexural strength of these mixes are tested and compared with the normal concrete by using the mix 1:1.5:3 at the end of 7 and 28 days. From the results it is found that replacement of cement with Rice Husk Ash and Egg Shell Powder in concrete upto an optimum amount gives better strength than conventional concrete.

Keywords— Concrete, cement, rice husk ash, egg shell powder, compressive strength, split tensile strength, flexural strength.

INTRODUCTION

Concrete is being widely used for the construction of structures due to its structural stability and strength. It is the backbone of infrastructure development of a nation. At present, for a variety of reasons, concrete industry is not sustainable. Firstly, it consumes a huge amount of natural resources due to which no virgin material will be left for future generations. Secondly the major component of concrete is cement and a large amount of greenhouse gas is being emitted in the manufacturing process of cement. It can be said that 7% of world carbon dioxide emission is attributable to Portland cement industry. Almost 900Kg of CO2 is produced during 1000Kg of cement production. Thirdly, concrete structures suffer from durability problems due to which natural resources are wasted. In this experiment, Rice husk ash and Egg shell powder are used as a supplementary cementitious material in concrete. Rice husk ash consists of non-crystalline silicon dioxide with high specific surface area and high pozzolanic reactivity. Also, calcium rich egg shells are a poultry waste with chemical composition nearly the same as that of limestone. Hence, the use of these materials in concrete can have benefits like minimising the use of cement, conserving natural lime and utilisation of waste materials.

Rice husk ash is one of the most widely available agricultural wastes in many rice producing countries around the world. Rice husk ash is unusually high in ash. The ash is 87-97% silica, highly porous and light weight, with a very high external surface area. Presence of high amount of silica makes it a valuable material for use in industrial applications. Other constituents of RHA , such as K2O, Al2O3, CaO, MgO, Na2O, Fe2O3 are available in less than 1%. Various factors which influence ash properties are incinerating conditions (temperature and duration),rate of heating, burning technique, crop variety and fertiliser used. The silica in the ash undergoes structural transformation depending on the conditions of combustion such as time and temperature. The production of chicken eggs on an industrial level leads to a considerable quantity of shell residue, which is considered as a waste or is used as a complement in agriculture. In general, egg shells are considered to have no economic value, even though they are rich in minerals and amino acids that could form the basis of several industries.

PREVIOUS RESEARCHES ON CONCRETES USING EGG SHELL AND RICE HUSK ASH AGE OF USE

Praveen kumar R & Vijayasarathy R[2010] used a combination of egg shell with silica fumes to find out the feasibility of egg shell as an alternative to cement. Egg shell powder replaces 10% ,20% & 30% in addition with the silica fume by 5%, 10% & 15% of weight of cement. M30 concrete was casted and the compressive strength, split tensile strength and flexural strength test as 7 & 28 days were done. Based on the experimental results they found out that the compressive strength with egg shell powder as cement replacement material increases upto 15 % without silica fume. Addition of silica fume also enhances the strength but in economical point of view only the egg shell powder replacement is sufficient enough for getting higher strength.

M. Sivakumar & Dr. N Mahedran [2005] centred on the growth of strength and permeability attributes of concrete by optimal substitution of cement with joint ratio of fly ash and RHA with synthesis egg shell powder. Fly ash and RHA with 4 distinct content of 5% , 20% & 30% in terms of weight were performed for substitution of cement and addition of a persistent 5% egg shell powder in every substitution. The restraints considered for analysis included compressive strength , split tensile strength , water permeability and sorptivity. The compressive and tensile strength of concrete increased with increased percentage of fly ash and RHA upto substitution with addition of egg shell powder of 7,14,28 and 56 days of curing . Their study has exposed the fact that15% fly ash + 15% RHA+ 5% ESP may be treated as a finest creation in view of the developed value of compressive strength , water permeability, reduced chlorine penetration and desirable functionability.

Mtallib and Rabiu (2009) carried out the investigation on properties of ESP as an admixture in concrete. They conducted a consistency test on ESP. It was observed that higher the contents of ESP in the cement , the faster the setting of cement. The decreased setting time of OPC was due to the addition of ESP as an accelerator.

EGG SHELL POWDER

Egg shell 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 the palisade layer constitutes the thickest part of the eggshell. The top layer is a vertical layer covered by the organic cuticle. The main ingredient in eggshells is calcium carbonate. The shell itself is about 95% CaCO3. The remaining 5% includes Magnesium, Aluminium, phosphorus, Sodium, Potassium, zinc, Iron, Copper, Ironic acid and Silica acid. 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 estimated that roughly 90 million tons of hen egg are generated throughout the world every year. In India 77.7 billion eggs are produced a year and about 190000 tonnes per annum of egg shell is generated.egg shell waste can be used as fertiliser, animal feed ingredient and other such uses. However, the majority of Egg shells are thrown away as a waste. The egg shells create some allergies when kept for a longer time in garbage. It also creates an undesirable smell which can cause irritation. Hence its Disposal is a great problem. This can be solved by using egg shell waste as a replacement to cement in concrete.

TABLE I. CHEMICAL COMPOSITION OF ESP

Contents	ESP (%)
CaO	50.7
SiO2	.09
Al2O3	.03
Fe2O3	0.02
MgO	0.01-0.04
SO3	0.5-1.3

RICE HUSK ASH

Rice husks are shells produced during the de-husking of paddy rice.1000 Kg of paddy rice can produce about 200 Kg of husk, which on combustion produces about 40 Kg of ash. Rice husk constitutes about 1/5th of the 300 million metric tons of rice produced annually in the world. The current yearly production of paddy rice is approximately 500 million tons that give about 100 million tons of rice husks as a waste product from the milling. Rice husk is also not used for feeding animals since it has less nutritional properties and its irregular abrasive surface is not naturally degraded and can cause serious accumulation problems. Research in India and the United States has found that if the hulls or straw are burned at a controlled low temperature, the ash collected can be ground to produce a Pozzolana very similar to (and in some ways superior to) silica fume and heat produced during burning can beneficially use in power production, by doing so not only crop waste can effectively disposed, but also can provide high quality cement. Pozzolanic activity of rice husk ash (RHA) depends on (i) silica content, (ii) silica crystallisation phase, and (iii) size and surface area of ash particles. The typical rice husk produced in India has organic amorphous silica (made of rice husk ash) with silica content of above 85%.

TABLE II. CHEMICAL COMPOSITION OF RHA

Sl.no	Contents	RHA (%)
1	CaO	0.3-2.2
2	SiO2	85-90
3	Al2O3	0.2
4	Fe2O3	0.1
5	MgO	0.2-0.6
6	SO3	0.25

TESTS ON ESP & RHA CONCRETE

Cubes of size 150x150mm, cylinders of size 150x300mm and beams of size 500x100x100mm were casted to check the compressive, split and flexural strength of concrete respectively. At first a control mix without any addition of RHA and ESP was prepared. Then concrete specimens were made using different percentages of egg shell powder(2.5,5,7.5&10%). After testing these specimens the optimum egg shell powder content in concrete was found. and By keeping this ESP content constant the specimens with varying percentages of RHA (5,7.5,10,15,& 20%) were made and tested .Three to six numbers of specimens of each combination were made for testing. Mix proportion of 1:1.5:3 with water cement ratio 0.45 was used for making concrete. But the water cement ratio was increased for increasing percentage of RHA due to low workability. The cement (also RHA,ESP) and fine aggregate was mixed dry until the mixture is thoroughly blended and is uniform in colour. The coarse aggregate was then added and mixed with the cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch, and Then water is added and the entire batch is mixed until the concrete appears to be homogenous and has the desired consistency. The curing of the specimen for 7 and 28 days testing was done by immersing the specimen in water.

TABLE III. MIX COMBINATION

Sl. No.	Mix Design	Cement (%)	ESP (%)	RHA (%)
1	M1	100	0	-
2	M2	97.5	2.5	-
3	M3	95	5	-
4	M4	92.5	7.5	-
5	M5	90	10	-
6	M6	90	5	5
7	M7	87.5	5	7.5
8	M8	85	5	10
9	M9	80	5	15
10	M10	75	5	20

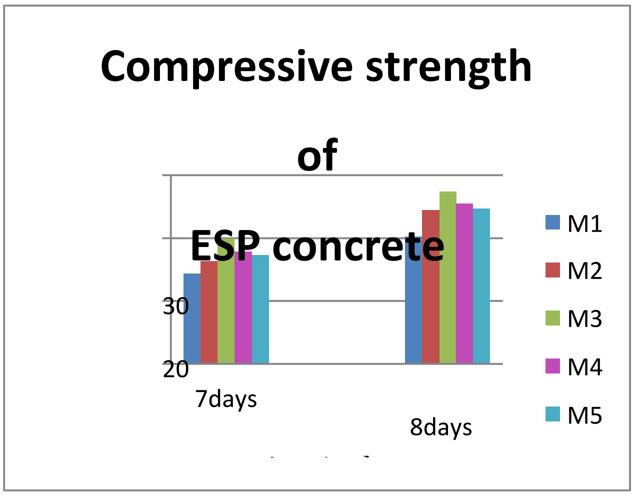
COMPRESSIVE STRENGTH TEST

The results of the compressive strength of cube specimens are present in table 5. The strength value reported for each mix is the average of strength of six cube specimens.fig 1 and fig 2 are the graphical representation of strength development of concrete cubes for various mixes. From the results it can be observed that the strength of the concrete increased with curing age for all mixes and the compressive strength of ESP concrete is higher than that of conventional concrete for every replacement levels. The maximum compressive strength of ESP concrete is obtained at 5% replacement of ESP for both 7 & 28 days of curing, this could be due to the chemical reaction between the ESP & alumina content in cement paste. When egg shell powder is increased beyond 5% there is gradual reduction in strength. This is due to an increase in $Ca(OH)_2$ content in concrete mix, which further increases the porosity of concrete.

TABLE IV. COMPRESSIVE STRENGTH

Mix name	7 days strength (N/mm^2)	28 days strength (N/mm^2)
M1	14.38	20.26
M2	16.36	24.49
M3	19.96	27.38
M4	17.88	25.53
M5	17.32	24.70
M6	14.55	21.58
M7	15.21	22.70
M8	15.76	23.48
M9	16.88	24.53
M10	10.42	17.35

FIG : COMPRESSIVE STRENGTH OF ESP CONCRETE



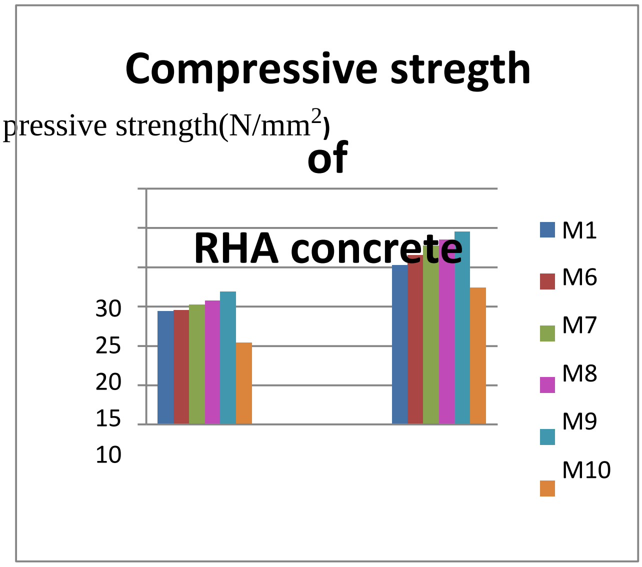


Fig 2 Compressive Strength of RHA Concrete

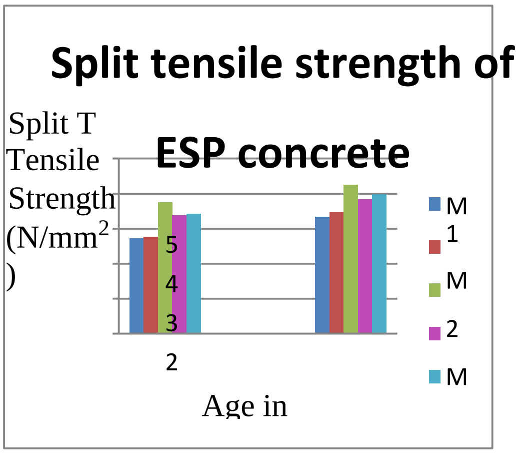
SPLIT TENSILE STRENGTH

The split tensile strength of all concrete mixes is shown in table V and figure 12 & 13 are the graphical representation of tensile strength development of various mixes. From the results it can be observed that addition of ESP increased the split tensile strength for both 7 and 28 days curing. The maximum split tensile strength is obtained at 5% replacement of ESP. Among ESP concrete the least strength is obtained at 2.5% replacement.

In the case of optimum ESP+RHA concrete, Up to 15% replacement of RHA, the split tensile strength is greater than control mix thereafter it has decreased. There is very less variation in results for different replacement levels in days testing. The reason for variation in result for different replacement levels is as said in the case of compressive strength.

TABLE V.SPLIT TENSILE STRENGTH

Mix name	**7 day Strength (N/mm^2)**	**28 day strength (N/mm^2)**
M1	2.73	3.34
M2	2.78	3.47
M3	3.76	4.26
M4	3.38	3.84
M5	3.43	3.98
M6	2.88	3.27
M7	2.67	3.81
M8	2.92	4.12
M9	3.05	4.23
M10	2.45	3.48



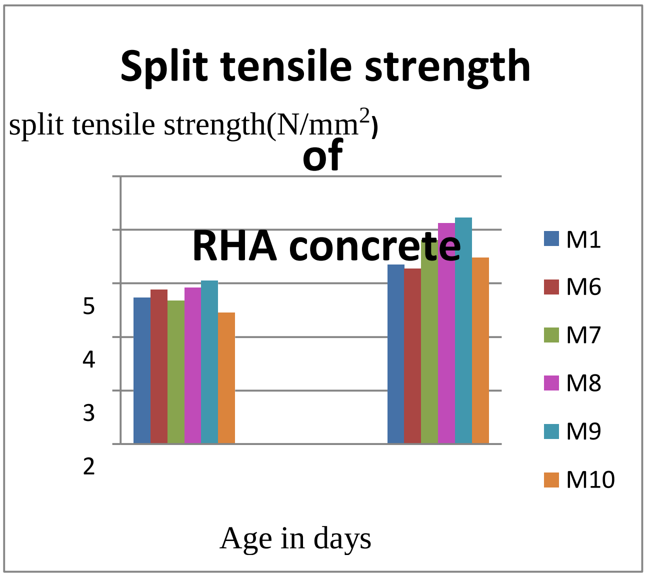


Fig 4 Split Tensile Strenth of ESP Concrete

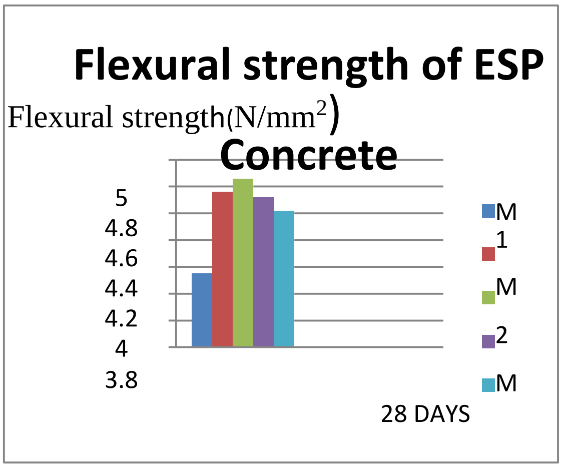
FLEXURAL STRENGTH TEST

TABLE VI. FLEXURAL STRENGTH

Mix name	**28 day strength (N/mm^2)**
M1	4.35
M2	4.96
M3	5.06
M4	4.92
M5	4.82
M6	4.43
M7	4.54
M8	4.78
M9	4.76
M10	4.26

The variation of flexural strength with respect to age and percentage of RHA and ESP is shown in table VI and it is graphically represented in fig 5 and 6.

It is seen that there is very less variation in flexural strength of concrete at various replacement levels. The maximum flexural strength is obtained at 5% replacement of ESP. The flexural strength of ESP and RHA concrete is obtained greater than conventional concrete except for 20% RHA replacement. Maximum flexural strength for optimum ESP+RHA concrete is attained at 10% replacement with RHA



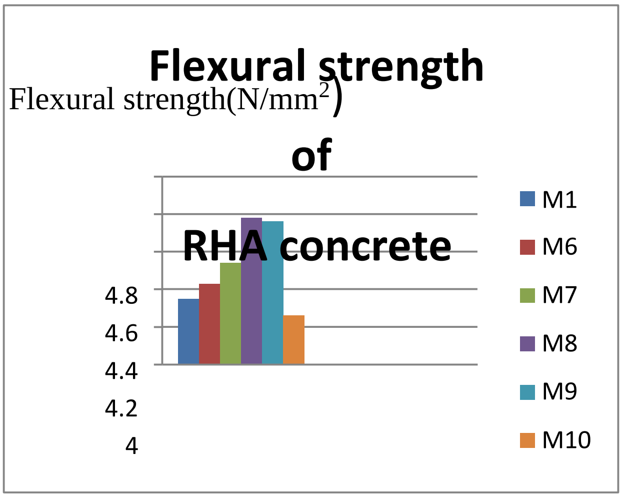


Fig 6 Flexural Strenth of RHA Concrete

CONCLUSIONS

In this study an afford has been taken to enlighten the use of rice husk ash and egg shell powder in concrete in accordance with their proficiency. From the results of tests of compressive strength, split tensile strength and flexural strength the following conclusions are made.

1) The quantity of water required to make a paste of standard consistency is more when cement is partially replaced with Rice husk ash and egg shell powder.
2) The compressive, split tensile and flexural strength of every Rice husk ash and egg shell powder concrete mix is higher than that of the control mix except for 20% Rice husk ash replacement.
3) The optimum percentage of egg shell powder content in concrete is obtained as 5%.
4) The maximum split tensile and compressive strength obtained for ESP+RHA concrete is at 15% of RHA & 5% ESP replacement level.
5) • The flexural strength of Rice husk ash and egg shell powder concrete is obtained similar to conventional concrete.
6) Compared to Rice husk ash concrete, Egg shell powder concrete had slightly higher early strength gain.RHA in concrete increases water demand due to its cellular structure.
7) The results obtained from present study shows that there is great potential for utilisation of ESP and RHA as a replacement to cement.
8) By using this Rice husk ash and egg shell powder in concrete as replacement the emission of greenhouse gases can be decreased to a greater extent.
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