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Experimental Study on Partial Replacement of Cement with Egg Shell Powder and Flyash with Rice Husk Ash in Brick

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Abstract: Approximately, yearly concrete production is about 10 billion cubic meters. Cement is a very important constituent of concrete, and approximately 4180 million tons of cement were produced in 2014 globally. Production of one ton of cement releases approximately one ton of CO2 which makes up 7% of all CO2 emissions produced globally. Hence, there is necessity touse supplementary cementitious materials (SCMs) as partial replacement of cement and sand in concrete. Utilization of SCMs reduces the consumption of Ordinary Portland cement, and thereby reduces the energy consumption and greenhouse gas emissions associated with cement production.

This research centres around the growth of the strength attributes of concrete by optimal substitution of cement with joint ratio of Rice husk ash (RHA) and Egg shell powder (ESP) with optimum joint ratio of sand replacement as Fly ash(FA). Initially ESP and RHA replaced with cement in proportion of 2.5%,5%,7.5%,10% and 5%,10%,15%,20% respectively. FA replaced with sand in proportion of 10%, 20%,30%, and 40%. Based on individual replacement results further ternary mix designs were carried out.

Keywords: **Fly ash, Rice husk ash, Egg shell powder, sand supplementary materials, compressive strength, split tensile strength.**

I. INTRODUCTION

It is a pressing need today for the concrete industry to produce concrete with lower environmental impact, these-called green concrete. This can be achieved in three ways. The first one is by reducing the quantity of cements one tonne of cement saved will save equal amount of CO2 to be discharged into atmosphere. Secondly by reducing the use of natural aggregates whose resources are limited and are exhausting very fast.

Fly ash is generally used as replacement of cement, as an admixture in concrete, and in manufacturing of cement. Concrete containing fly ash as partial replacement of cement poses problems of delayed early strength development. Concrete containing fly ash as partial replacement of fine aggregate will have no delayed early strength development, but rather will enhance its workability and strength.

This higher workability and strength achieved gives scope for indirectly reducing the cement quantity in concrete. India is a major rice producing country, and the husk generated during milling is mostly used as a fuel in the boilers for processing

paddy, producing energy through direct combustion and / or by gasification. About 20 million tons of RHA is produced annually. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped. India is in fifth position in the world annual egg production.

About 1.61 million tons of egg shells are being waste annually by disposing it as a landfill, which attracts vermin due to attached membrane and causes problems to human health and environment. Maisarah Ali et al (2015) introduced RHA as the micro filler in concrete mixtures.

The replacement of RHA which is lighter asmcompared to the Ordinary Portland Cement results in decreasing density of cement fibre composite and less permeable concrete. 5% of RHA was used as cement replacement material for target strength of 50MPa. Microstructure properties of both mixes were

analysed using FESEM. Higher silica contains in concrete cubes containing RHA led to the greater formation of calcium Silicate Hydrate (CSH) that contributed towards strength development to the concrete during curing. Water absorption of concrete with RHA replacement is lower than concrete without RHA.

The compressive strength test of concrete with 5% RHA replacement is lower than without RHA replacement. However, the target compressive strength of is achieved.

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II. EXPERIMENTAL INVESTIGATION

A. *Materials and Method*

1) *Cement:* Ordinary Portland cement of 43 grade (Ramco) conforming to IS 8112-1989 is used. Table 1 shows the test results of basic properties of cement.

Table 1: Basic Properties of Cement

Properties	Results
Specific gravity	3.15
Standard consistency	32%
Initial setting time	38min
Final setting time	480min
fineness	5.3%

Table 2. Chemical Analysis for Cement.

SiO_2	21.3
CaO	63.14
Fe_2O_3	3.77
Al_2O_3	5.41
MgO	1.2
Na_2O	0.56

2) *Fine Aggregate:* Natural river sand of size below 4.75mm conforming to zone III of IS 383-1970 was used as fine aggregate. Table 3 shows the test results of basic properties of fine aggregates.

Table 3: Basic Properties of Fine Aggregates

Properties	Results
Specific gravity	2.60
Water absorption	1.45%

3) *Coarse Aggregate:* Natural crushed stone with 20mm down size was used as coarse aggregate. Table 4 shows the test results of basic properties of coarse aggregates.

Table 4: Basic Properties of Coarse Aggregates

Properties	Results
Specific gravity	2.65
Water absorption	0.39%

4) *Egg Shell powder:* Eggshell consists of several mutually growing layers of $CaCO_3$, 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 has calcium, magnesium carbonate (lime) and protein. In many other countries, it is the accepted practice for eggshell that first it is drying and then it is using as a source of calcium in animal feeds. For this study I collected broken egg shells from college and canteen outside restaurants. First the shells boiled in water to clean from other materials and dried it in air for four days approximately at a temperature range of 25-30^{0}C. Then I crushed it by hand, grinded and sieved through 90µm.materials passed through 90µm sieve was used for cement replacement.

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Table 5: Basic Properties of ESP

Properties	Results
Specific gravity	1.94
Water absorption	5.95%

Table 6.Chemical Analysis for ESP

S. NO	OXIDE CONTENTS	PERCENTAGE (%)
1	CaO	60-67
2	SiO_2	17-25
3	Al_2O_3	3-8
4	Fe_2O_3	0.5-6.0
5	MgO	0.1-4.0
6	K_2O, Na_2O	0.4-1.3
7	SO_3	1.3-3.0


Fig: 1. Providing Egg shell powder


Fig: 2 Egg shell powder

B. Rice Husk Ash

Rice husk ash is obtained from local supplier. Rice husk has about 75 % organic hot-tempered material which burns up and the balance 25 % of the weight of this husk is converted into ash during the firing process, which is known as rice husk ash (RHA). For making rice husk ash rice husk is burning approximately 1148 hours under uncontrolled burning process. The burning temperature is within the range of 600 to11850 C^0. The ash obtained is ground in a ball mill near about for 30 minutes and color of rice husk ash is seen as grey. This RHA contains around 85%-90% amorphous silica. India is a major rice producing country, about 20 million tons of RHA is produced annually. This RHA is a great environment warning causing damage to the land and the surrounding area in which it is vacant. Lots of ways are being thought of for disposing it by making commercial use of this RHA. In the present investigation, Portland cement was replaced by rice husk ash at various percentages to study compressive andflexural strength.

Table 7.Basic Properties of rice husk ash.

PROPERTIES	SPECIFICATION
Appearance	Grey Black
Bulk Density (gm/cc)	0.58
Moisture at 105^oC	1.87%
Loss On Ignition	< 6.0%
Residue on 350µ mesh	< 0.5%

Table 8: Chemical Analysis for Rice Husk Ash

SiO_2	92.89
Fe_2O_3	0.43
Al_2O_3	0.18
CaO	1.03
MgO	0.35
SO_3	0.1
$Al_2O_3 + Fe_2O_3$	0.61
Na_2O	3.56
	0.72

Fig:3 Rich husk Ash

1) *Mix Proportions and Casting of Concrete Specimens:* All mixes were prepared with different proportions with rice husk ash and egg shell powder replaced by cement and fly ash replaced by sand in conventional M30 Grade concrete. Mix design is carried out as per IS 10262:2009. In the initial stage, chemical composition, physical traits, and categorization of FA, RHA and ESP were executed. In the second stage, concrete mixes with different proportion of individual supplementary material was carried out. Each control mix were prepared with constant water to cement ratio of 0.44. compressive strength and tensile strength test were carried out for each mix and analysing the results. In the third stage, based on results of individual replacement further mix designs were conducted. Replacement of 5% ESP by weight with cement was taken as constant for further mix designs. Compressive strength tensile strength and acid attack tests were carried out for each mix and analyse results.
2) *Compressive Strength of Brick:* Compressive strength of cement concrete cube of all blends were calculated in accordance with provisions of IS 9013-1997 after 7 and 21 days of curing, and these were experimented on digital compression testing machine according to I.S. 516-1959.

Mixing Of Composition Laying Of Bricks

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Testing Specimen


After Testing

7 DAYS TEST

MATERIAL	% OF MATERIAL	WEIGHT(kg)			LOAD (kn)		
RICE HUSK		T1	T 2	T3	T1	T 2	T3
	CONVENTIONAL	3.245	3.615	3.154	145	165	180
	10 %	3.340	3.046	3.540	124	146	132
	20%	3.450	3.056	3.191	150	184	168
	30%	3.562	3.941	3.843	125	130	135
	40%	3.290	3.212	3.124	140	125	140
EGG SHELL	5%	3.356	3.105	3.108	136	196	172
	10%	3.458	3.540	3.453	153	158	164
	15%	3.378	3.685	3.812	121	121	110

14 DAYS TEST

MATERIAL	% OF MATERIAL	WEIGHT(kg)			LOAD (kn)		
RICE HUSK		T1	T 2	T3	T1	T 2	T3
	CONVENTIONAL	3.149	3.392	3.644	221	198	224
	10 %	3.210	3.060	3.104	315	314	301
	20%	3.114	2.944	3.062	206	285	225
	30%	2.870	2.878	2.850	185	199	190
	40%	2.993	2.927	2.853	200	205	199
EGG SHELL	5%	3.166	3.335	3.215	235	210	215
	10%	3.130	3.182	2.892	196	209	190
	15%	2.666	2.736	2.680	165	172	168

21 DAYS TEST

MATERIAL	% OF MATERIAL	WEIGHT(kg)			LOAD (kn)		
RICE HUSK ASH		T1	T 2	T3	T1	T 2	T3
	CONVENTIONAL	3.089	3.207	3.158	322	313	308
	10 %	2.987	3.225	3.078	365	380	352
	20%	2.910	2.972	3.081	356	348	323
	30%	2.905	2.955	2.898	304	310	312
	40%	2.821	2.966	2.578	263	281	295
EGG SHELL	5%	3.028	3.097	3.051	316	295	302
	10%	2.970	2.786	3.012	267	278	291
	15%	2.796	2.727	2.931	260	243	285

WATER ABSORBTION TEST AFTER 21 DAYS

MATERIAL	% OF MATERIAL	BEFORE 24 HOURS	AFTER 24 HOURS	DIFFERENCE
RICE HUSK	CONVENTIONAL	3.238	3.635	0.379
	10%	2.991	3.154	0.163
	20%	3.234	3.498	0.264
	30%	3.015	3.291	0.276
	40%	3.151	3.575	0.424
EGG SHELL	5%	3.105	3.419	0.314
	10%	3.078	3.368	0.290
	15%	3.715	3.122	0.593

III.CONCLUSION

Based on limited experimental investigation concerning the compressive & split strength of concrete, the following conclusions are drawn:

A. Compressive strength reduces when cement replaced fly ash. As fly ash percentage increases compressive strength and split strength decreases
B. Use of fly ash in concrete can save the coal & thermal industry disposal costs and produce a „greener concrete for construction.
C. The cost analysis indicates that percent cement reduction decreases cost of concrete, but at the same time strength also decreases.
D. This research concludes that fly ash can be innovative supplementary cementitious Construction Material but judicious decisions are to be taken by engineers.

Based on the experimental investigation the following conclusion are drawn

1) Egg shell concrete gives greater flexural strength compared to concrete without egg shell powder.
2) Egg shell concrete had less split tensile and compressive strength compared to concrete without egg shell powder.

C.Optimum flexural strength is obtained at 5% replacement of egg shell power concrete

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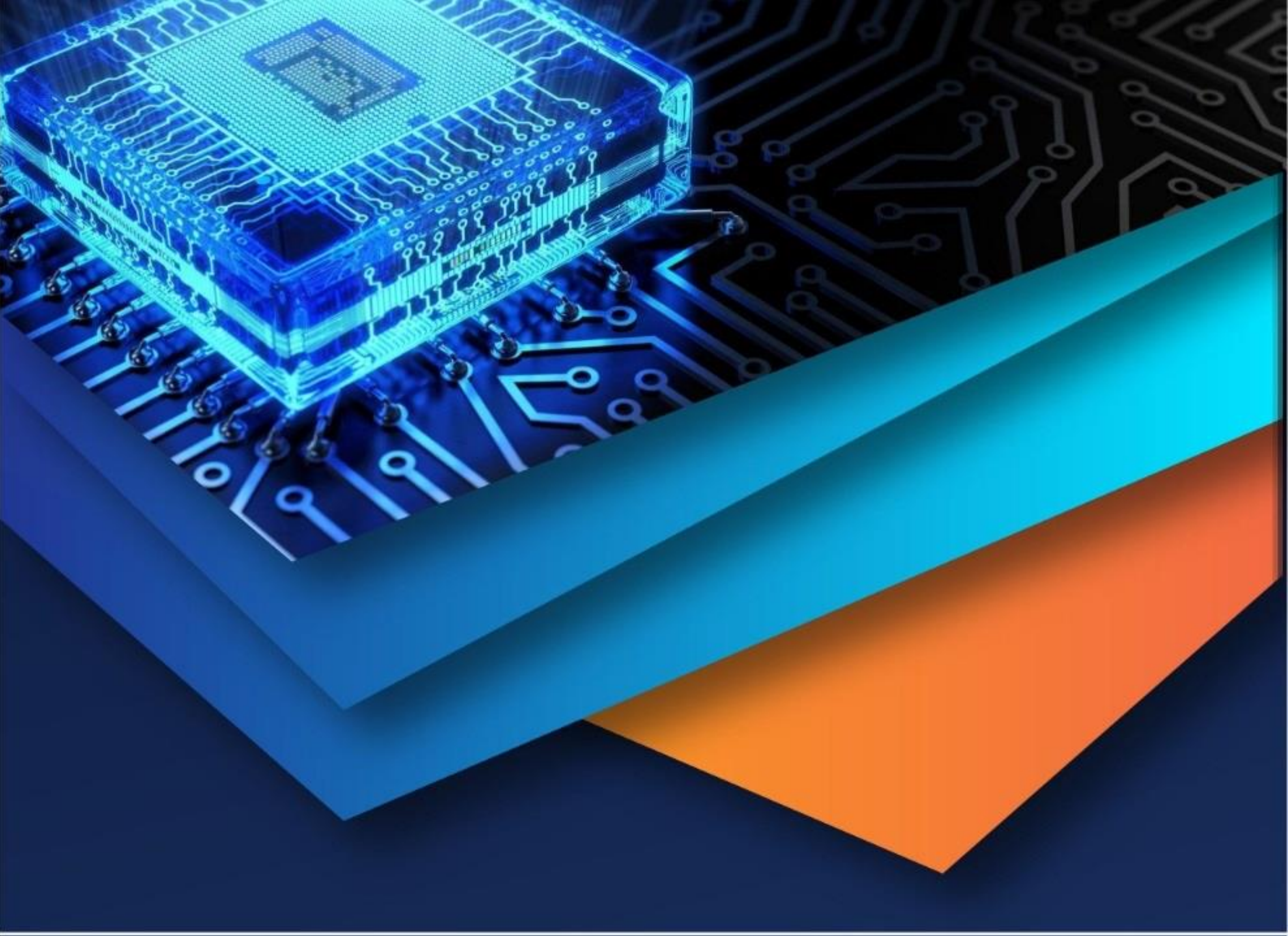

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