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STRENGTH AND PERMEABILITY PROPERTIES OF CONCRETE USING FLY ASH (FA), RISE HUSK ASH (RHA) AND EGG SHELL POWDER (ESP)

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ABSTRACT

This research centers around the growth of the strength and permeability attributes of concrete by optimal substitution of cement with joint ratio of Fly ash (FA) and Rice husk ash (RHA) with Synthesis Egg shell powder (ESP). Two categories of ash such as fly ash, rice husk ash with four distinct contents of 5%, 10%, 20%, 30%, and 40% in terms of weight were performed for the substitution of cement and addition of a persistent 5% egg shell powder in every substitution. At first we have evaluated the physical and chemical attributes of fly ash, rice husk ash and egg shell powder. The restraints considered for analysis included compressive strength, splitting tensile power, flexure force, water permeability, sorptivity, total charge-passed acquired from swift chloride permeability test (RCPT) and tempo of chloride ion diffusion according to the diffusion coefficient. However, assessment results accomplished underscore the point that strength and permeability properties of concrete significantly jumping up to 30% of cement substitution by combined FA (15%), RHA (15%) with additive ESP (5%), and subsequently tends to drop down with every supplementary accumulation of substitution outside this level.

Key words: *Fly Ash, Rice Husk Ash, Egg Shell Powder, Compressive Strength, Sorptivity*

1. INTRODUCTION

It is observed that various study reports have been brought to light as regards the assessment of individual efficiency of Fly ash and Rice husk ash blended concrete. Nevertheless, there is a scarcity in respect of the study reports which focused on the joint execution of fly ash and rice husk ash. The underlying reason for the current exploration is to precisely assess Fly ash, Rice husk ash (RHA) and Egg shell powder (ESP) chemically, physically and miner logically differentiated, to explore the feasibility of their employment as a cement-substituting substance in the concrete industry

Fly ash is the utmost general pozzolan and is found extensively applied universally in concrete works. It is universally acknowledged that the employment of fine fly ash upgrades the qualities of mortar and concrete [9, 24]. Even though the porosity of the paste is enhanced on account of the inclusion of fly ash, the average pore size gets decreased, resulting in a minimal porous paste [9, 25]. The interfacial domain of the interface between aggregate and the matrix also gets refined in view of the employment of the use of fly ash [9, 26]. It is estimated that in India, the entire coal ash production exceeded 10 core tons in 2010. With an eye on scaling up the employment of fly ash, and to fine-tune the property of concrete, several investigators have resorted to employment of large volumes of Class F fly ashes in concrete.

The supplementary pozzolanic agent from agriculture by-products like rice husk ash (RHA) are emerging as hot topics of incessant investigation. Rice husk ash consists of high silica substance in the shape of non-crystalline or amorphous silica. Hence, it is a pozzolanic material which can be employed as additional cementitious objects (9). Rice husk is an agricultural remainder derived from the external covering of rice grains during milling procedure. It comprises 20% of the 500 million tons of paddy generated in the world

Eggshells are agricultural throw away objects produced from chick hatcheries, bakeries, fast food restaurants among others which can damage the surroundings and as a result comprising ecological issues/contamination which would need appropriate

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treatment. In the ever soaring tasks to change waste to wealth, the efficiency of adapting eggshells to advantageous application constitutes a concept worth-accepting. It is systematically acknowledged that the eggshell chiefly consists of compounds of calcium. Okonkwo [16] has proficiently proposed that eggshell comprises 93.70% calcium carbonate (in calcium), 4.20% organic matter, 1.30% magnesium carbonate, and 0.8% calcium phosphate. It is estimated that roughly 90 million tones of hen egg are generated throughout the world every year. In India 77.7 billion eggs are produced in the year 2010-2011.Tamil Nadu, amassing a share of around 20 per cent, is ranked second with almost 2,000 core eggs created in the state every year. The next in the list of prominent egg producing states in India comprise Maharashtra, Haryana, Punjab and West Bengal.

With this end in view, tests were performed in three stages as per normal test processes. In the initial stage, chemical composition, physical traits, and categorization of Fly ash (FA), Rise husk ash (RHA) and Egg shell powder (ESP) were executed. This comprised assessment of normal steadiness, preliminary setting period, concluding setting period and compressive strength of RHA blended cements. In the second stage, investigation on concrete specimens was performed. This consisted of experiments on compressive strength, splitting tensile strength and flexural strength. In the third phase, coefficient of water absorption, sorptivity, resistance to chloride ion penetration and diffusion coefficient were estimated. All the tests were executed in triplicate and mean values are recorded and communicated.

2. EXPERIMENTAL INVESTIGATION

2.1. Materials and Method

2.1.1 Materials Used

Ordinary Portland cement (OPC) 43 grade of specific gravity of 3.15 in compliance with Indian standard code IS 8122 -1995 (21) was employed. Graded river sand passing through 4.75 mm sieve with fineness modulus of 2.75 and specific gravity of 2.56 was utilized as fine aggregate. The coarse aggregate was regionally accessible compacted granite aggregate, passing through 12.5 mm sieve and maintained on 4.75 mm sieve with fineness modulus of 6.64 compliant to IS 383-1970 (24)

Fly ash for the purpose of this investigation was obtained from Mettur Thermal Power Plant (MTSP) in Tamilnadu. From the resources, class F type fly ash of size 45 µm was gathered. It is desirable that to all constraints of fly ash compliant to substitution of IS 3812 -1981(22) & ASTM C618 are limited for class F fly ash for employment in concrete.

Rice husk residue was gathered from a rice mill at Dindigul by-pass road, Dindigul district in Tamil Nadu, India. At the outset, rice husk was transformed into ash by means of open burning technique at a temperature, within a range of 300 ^{0}C to 450 ^{0}C. The quantity of un- burnt carbon was found in the resulting ash at a temperature below 600 ^{0}C. The fired husk residue ash was black in color clearly owing to surplus quantity of carbon content. The mill fired husk residue ash was again burnt a temperature of 650^{0} C over a period of 1 h and to a mean grain size of 3.8 µm before it was employed as a cement substitute substance (1).

Egg shells were obtained from Namakkal in Tamil Nadu which is regarded as India's egg export hub and which is responsible for over 90 % of India's total egg exports. The average weight of one egg shell was found to be 7.2 to 7.8 gm. Egg shell was cleaned completely with a view to do away with organic properties and dried in sun light for 5 to 7 days and to make powder attained an average particle size of 45 µm

The Naphthalene based Super Plasticizer (Rheoblast N198) which is light brown Color and free flowing liquid with Relative density 1.09±0.01 and pH value as ≥ 6and Chloride Content <0.2% was employed as Super Plasticizer. Optimum dosage of should be assessed with trial mixes. As a guide, a dosage range of 500 ml to 1500ml per 100kg of cementitious material is generally advised.

2.1.2 Physical and Chemical Analysis

Particle size allocation of OPC, Fly ash, RHA and Egg shell powder was decided. Physical properties such as specific gravity, bulk density, and fineness of OPC (IS 8122-1985), Fly ash (IS 1727- 1967), RHA (IS1727-1995) and Egg shell powder were calculated. Specific surface area of OPC, FA and ESP were calculated as per IS 4031 (part 2)-1995 by means of Blain's air permeability tool (1). Definite surface area of RHA was calculated by using BET's technique by nitrogen adsorption (1). The physical properties of OPC, FA, RHA and ESP are contrasted in Table 1 Chemical examination for oxide composition of OPC (IS 4032-1985), Fly ash (IS3812-1981), RHA and Egg shell powder was calculated. Chemical composition data for OPC and all composite material are contrasted in Table 2.

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Table: 1 Physical property of Cement, FA, RHA and ESP

Material	Property			
	Specific gravity	Finesse modules/ Finesse (%)	Bulk density Kg/m^3	Surface area
Cement	3.10	1%	-	348 m^2/kg
Fly ash (FA)	2.07	2.5%	1190	527 m^2/kg
Rice husk ash (RHA)	1.98	1.6%	696	34.60 m^2/g
Egg shell powder (ESP)	1.89	4.1%	1081	290 m^2/kg
Fine aggregate	2.56	2.75	1693	-
Coarse aggregate	2.70	6.64	1527	-

Table: 2 Chemical compositions of Cement, FA, RHA and ESP

Binder	Chemical composition (%)									
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	LOI	SiO_2+ Al_2O_3+ Fe_2O_3
Cement	20.09	5.08	3.18	62.98	3.00	0.12	0.48	2.10	2.98	
FA	53.68	23.07	10.03	2.98	2.16	0.52	0.94	0.18	2.47	86.78
RHA	87.65	0.22	0.24	0.39	0.28	1.10	2.98	0.15	2.26	88.11
ESP	0.09	0.44	0.34	32.51	0.14	0.17	-	0.37	3.74	
IS 3812 – 1981 requirement	35.0 min				5.0 max	1.5 max		2.75 max	12.0 max	70.0 min
ASTM C 618 requirement					5.0 max	1.5 max		5.0 max	6.0 max	70.0 min

2.1.3 PH Value Mix Proportions

PH value of cement and different mix designation of RA_0 to RA_5 (Table no.4) are estimated by means of PH meter. PH meter is calibrated by immersing it in distilled water for 24 hrs. 100 grams of cement and 100 ml of water mixed in a beaker for about 5 minutes and Ph meter is dipped completely in the mixed slurry and the value is recorded. These processes were done again and again as RA_0 for standard and RA_1-RA_5 for (Fly ash, RHA and ESP) concrete

Fig.1. PH Value of mix proportions

2.1.4 Consistency and Setting Time of Blended Cement

In accordance with provisions of IS 4031 (part 4) – 1995 standard consistency of cement RA_0-RA_5 was assessed and opening and concluding setting time were assessed according to IS 4031 (Part – 5) – 1995.

2.1.5 Soundness Test for Mix Proportions

Vide the extant provisions of IS 4031 (part 3) – 1995 soundness test (volume changes) of cement the mix designation of RA_0 to RA_5 were estimated the investigation outcomes are scrutinized as per relevant sections of IS 12269-1987

2.1.6 Mix Proportions and Casting of Concrete Specimens

OPC (43 Grade) is partly substituted with pozzolans at the dosage of 0–50% by weight of cementitious materials. Double pozzolan and a mixture of various weight parts of Fly Ash, RHA and additive of Egg shell powder of 5% at each substitution along with the control mix were organized with a water to binder W/(C + FA + RHA + ESP) ratio of 0.5 for a design cube compressive strength of 25 MPa. These mixes were represented as RA_0 for control and RA_1–RA_5 for ESP concretes. The blend proportions are offered in Table 3 and mix propositions symbol are furnished in table no.4

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Table: 3 Mix proportions of ESP concretes

Mix designation	Cement Kg/m^3	Fly ash Kg/m^3	Fly ash %	RHA Kg/m^3	RHA %	Egg shell powder Kg/m^3	Egg shell powder %	% of replacement	Slump mm
RA_0	383	-	-	-	-	-	-	0	135
RA_1	363.8	9.58	2.5	9.58	2.5	19.15	5	5	130
RA_2	344.7	19.15	5	19.15	5	19.15	5	10	120
RA_3	306.4	38.3	10	38.3	10	19.15	5	20	113
RA_4	268.1	57.45	15	57.45	15	19.15	5	30	90
RA_5	229.8	76.6	20	76.6	20	19.15	5	40	81

Water to binder ratio [C + (Fly ash, RHA and ESP)] 0.5; sand 575 kg/m^3, aggregate 1150 kg/m^3 and Super Plasticizer 4600ml/m^3

Table: 4 Mix proposition Symbol

Mix designation	Symbol	Cement (%)	Replacement (%) FA	Replacement (%) RHA	Additive (%) ESP
RA_0	OPC	100	-	-	-
RA_1	2.5FA2.5RHA5ESP	95	2.5	2.5	5
RA_2	5FA5RHA5ESP	90	5	5	5
RA_3	10FA10RHA5ESP	80	10	10	5
RA_4	15FA15RHA5ESP	70	15	15	5
RA_5	20FA20RHA5ESP	60	20	20	5

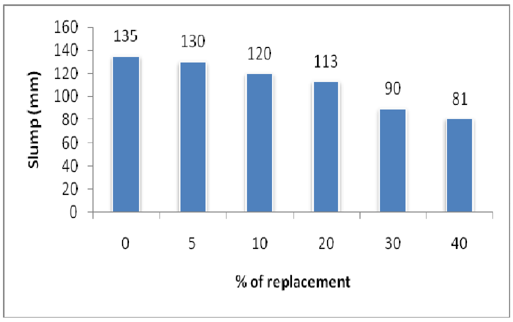

Fig.2. Slump Value Of Different Mix Proportion Of ESP Concrete

2.1.7 Compressive Strength of Concrete

Compressive strength of combined cement concrete cube with diverse blend designation of RA_0 to RA_5 was calculated in accordance with provisions of IS 9013-1997 after 7,14,28,56 and 90 days of immersed water curing, and these cubes were experimented on digital compression testing machine according to I.S. 516-1959[18].

2.1.8 Splitting Tensile and Flexural Strength of Concrete

Vide IS 5816-1999(19) and IS 516-1959[18], Splitting tensile strength(cylinder) and flexural strength(beam) was executed on ESP concrete of blend designation of RA_0 to RA_5 after 7, 28 and 90 days of curing.

2.1.9 Coefficient of Water Absorption

Coefficient of water assimilation is recommended as a dimension of permeability of water [11]. This was assessed by the degree of uptake of water by dry concrete in a period of 1 h (1, 5). The concrete cube specimens were dried in an oven at 110^{0}C for seven days until constant weight was attained and then permitted to cool in a concealed container for one day. The sides of the concrete samples were covered with crystal clear wax sealant resin with a view to facilitate the flow in one direction. Then the samples in a vertical position were set aside partly absorbed to a depth of 5 mm at one end while the remainder of the parts were kept uncovered to the laboratory air as shown in Fig. 5. The quantity of water absorbed during the first 60 min was estimated. Coefficient of water absorption values of concrete specimens after 28 and 90 days of moisture curing were assessed by means of the formula (1 & 5),

$$Ka = (Q/A)^2 \; X\, 1/t$$

Where Ka is the coefficient of water absorption (m^2/s), Q is the quantity of water absorbed (m^3) by the oven dry specimen in time (t), t is 3600 s and A is the surface area (m^2) of concrete specimen through which water penetrates.

2.1.10 Sorptivity

Sorptivity test is extensively employed to assess the capillary rise water absorption rate in to the harmonized material. Concrete cube specimens casted and dried in an oven at 40 to 50 ^{0}C for four days after 28 days of immersed water curing. The concrete specimen facilitated cooling in a room temperature for two days. The side of the concrete specimen was covered with wax sealant except the test surface on down and top of sample kept free of wax sealant. The preliminary weight of the concrete cube with 0% substitution was considered with no time lag. The concrete cube specimen was preserved partly absorbed to a depth of 5mm in the water as illustrated in Fig. 3. The specimen masses were noted at time intervals of 1, 2, 4, 6, 8, 10……….250 and 300 min. The specimens were

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swiftly detached from the water, had its test surface patted with a paper towel to eliminate surplus water and the model was weighed. The sorptivity values of Egg shell powder concrete specimens after 28 and 90 days of moisture curing were estimated by the following formula,

$$i = S\sqrt{t}$$

Where i is the cumulative water absorption per unit area of inflow surface (m^3/m^2), S is the sorptivity ($m/s^{1/2}$) and t is the time elapsed (s).

Fig.3. Coefficient Of Water Absorption Test And Sorptivity Test

2.1.11 Rapid Chloride Ion Penetration Test (RCPT)

This investigation was carried out in accordance with ASTM C1202-09. Concrete disc of size 90 mm diameters and 50 mm thickness were cast and permitted to cure for 28 days. After curing, the concrete specimens were furnished to RCPT test by impressing a voltage of 60 V. Two halves of the specimens are preserved with PVC container of diameter 90 mm.

One side of the container is packed with 3% NaCl solution connected to the negative terminal of the power supply, the other side is full of 0.3 N NaOH solution connected to the positive terminal. Current is calculated at half-hourly intervals up to a maximum 6 hours. Chloride contamination and temperature was also scrutinized every half hour. From the outcomes by the use of current and time, chloride permeability is determined in terms of Coulombs at the end of 6 hours. Fig.6 illustrates the Rapid Chloride Penetrability experimentation in advancement, Fly ash, RHA with egg shell powder concrete specimens after 28 days of curing was supervised by occasionally by dispensing with minimal aquilots and determination the chloride concentration of these models, till a consistent stage was attained (120 h). Chloride diffusion coefficients were estimated by means of Nernst–Einstein equation (1,27)

$$D \frac{JRTL}{ZFC_0E}$$

Where, D is the chloride diffusion coefficient (cm^2/s), J is the flux of chloride ions (mol/cm^2s),

R is the gas constant (8.314 J/K mol), T is the absolute temperature (300K),

L is the thickness of the specimen (cm), Z is the valency of chloride ion (Z = 1),

F is the Faradays constant (9.648×10^4 J/Vmol),

C_0 is the initial chloride ion concentration (mol/l), E is the potential applied (60 V).

Fig.4. Rapid Chloride Ion Penetration Test (RCPT)

2.1.12 Water Permeability Test

High Pressure water Permeability test for concrete cube specimens was calculated in terms of IS3085 -1997(17).The test cube specimen was kept dried for two days after 28 and 90 days moisture curing. The investigation concrete models are preserved by means of molten wax compound in the cells to block any outflow along the side walls. The top surface of the specimens was covered with a piece of paper and "O"- ring to check the sealing compound from the blocking the face. After it is sufficiently sealed, it should safely bolt the bottom plate and funnel in place. Then the cell has to be mounted on the stand and connected to pressure chamber. At this time, an input air pressure of 15 kg/cm^2 and test pressure of 10 kg/cm^2 have to be applied. Moreover, the pressure must be controlled by rotating the handle of pressure in clockwise direction and the opening the release valve. Now the quantity of water passing through the cube every one hour period must be collected until the identical velocity of flow is attained. The coefficient of permeability is determined by means of the following formula

$$K = \frac{Q}{AT\ X\ H/L}$$

K = Coefficient of permeability in cm/sec

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Q = Quantity of in milliliters percolating over the complete period of test after reaching the consistent phase

A = Area of the specimens face in cm^2

T = Time in seconds over which Q is determined

H/L = Ratio of the pressure head to the thickness of models

3. RESULT AND DISCUSSION

3.1 PH Value Mix Proportions

The quantity of chloride needed for stimulating corrosion is partially based on the pH value of the pore water in concrete. At a pH value within 11.5 corrosion happens in the absence of chloride. At pH exceeding 11.5 a significant quantity of chloride is essential. (28). Table.4 and Fig. 9 illustrate that the pH value of blend ratio of RA_1 to RA_5 is at least 11.5 it is desirable for decomposition inhabiting concrete. R.N.Krishna (15) cleverly includes the ph value of rice husk ash concrete (M30) in the domain of 11.3 – 11.7

3.2 Soundness Test for Mix Proportions

"Soundness" indicates the capability of a hardened cement paste to keep up its volume after setting in the absence of belated growth. This growth is triggered by surplus amounts of free lime (CaO) or magnesia (MgO). Many of the Portland cement stipulations restrict magnesia content and growth. The cement paste is not to be subjected to significant variations in volume after it has fixed itself firmly. Anyhow, while redundant quantities of free CaO or MgO are there in the cement, these oxides can gradually hydrate and result in growth of the toughened cement paste. Table 5 and Fig.10 show the soundness value of various blend ratio of $RA_{0\,-}RA_5$

Table: 5 Soundness Test For Different ($RA_{0\,-}RA_{5}$) Mix Proportions

Mix designation	Symbol	pH Value	Soundness value(mm)
-	Water	7.2	
RA_0	OPC	12	1
RA_1	2.5FA2.5RHA5ESP	11.96	3.5
RA_2	5FA5RHA5ESP	11.96	3
RA_3	10FA10RHA5ESP	11.94	2.5
RA_4	15FA15RHA5ESP	11.88	1.5
RA_5	20FA20RHA5ESP	11.92	2

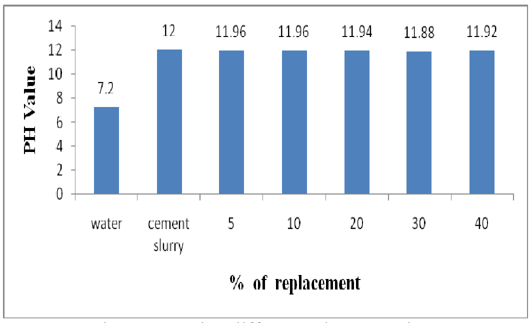

Fig.5. PH Value different mix proportions

3.3 Consistency and Setting Time of Blended Cement

The diverse percentage of cement replacement level (CRL) versus standard consistency graph (Fig. 6) shows that the water needed for standard consistency linearly goes up with an enhancement in substitution (RA_1 – RA_5) content. As ashes are hygroscopic in character and the definite surface area of our composite material (Fly ash, RHA and ESP) is considerably larger than cement, it required additional quantity of water.

The percentage of CRL versus opening and concluding setting time chart represented by Fig. 6 & Table.6 illustrate the fact that up to 20%, enhancing the periods greater than those of OPC and the finer particles of Fly ash RHA are significantly ordered in their allocation. If further raise in substitution percentage is made, opening and concluding setting period tend to decrease.

Table: 6 Consistency And Setting Time Of ESP Cement

Mix designation	Symbol	Consistency (%)	Setting time (min)	
			Initial	Final
RA_0	OPC	31	65	265
RA_1	2.5FA2.5RHA5ESP	33	95	225
RA_2	5FA5RHA5ESP	33	115	220
RA_3	10FA10RHA5ESP	37	130	210
RA_4	15FA15RHA5ESP	39	119	195
RA_5	20FA20RHA5ESP	42	135	225

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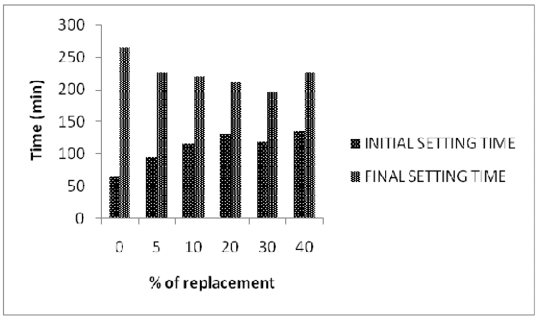

Fig.6. Initial And Final Setting Time Of ESP Cement

3.4 Compressive Strength of Concrete

The compressive strengths of ESP cement mortars are exhibited in Table 7. Assessment of the data for 3, 7 and 28 days of curing time reveals the fact that the compressive strength goes up to RA_4(15FA15RHA5ESP). Anyhow, at RA_6, the compressive strength comes down to a value below that of control concrete. Hence, RA_4 (15FA15RHA5ESP) is taken as an enhancement in strength as depicted in Table.7

The enhancement in strength is partly due to the pozzolanic responses as revealed by several investigators (1, 4, 5, and 9). P. Chindaprasirt, S. Rukzon (9) have characteristically brought to light through their investigation that the strength of cement mortar having 15% FA + 15% RHA (15FA15RHA) is marginally greater than that of the OPC mortar at the identical age of 28 days. However in a period of 90 days 20% FA + 10% RHA is somewhat superior to 15% FA + 15% RHA. K. Ganesan et al (1) have gallantly revealed that the compressive strength enhances RHA blended cement mortars 15% cement substitution. Anyhow, 30% RHA, the compressive strength attains the identical strength as that of control mortar. C.S. Poon et al (4) have proficiently thrown light on the fact that at a w/b of 0.24, the strength values as the pastes with 25% fly ash at the age of 28 days, exhibit superior comparative strength value to the equivalent paste. At the age of 90 days, identical outcomes have been obtained for the pastes and concrete at the w/b of 0.19

Table: 7 Mix Proportion And Compressive Strength Of Egg Shell Powder (ESP) Cement Mortarst

Mix designation	Symbol	Compressive strength of cement mortar (MPa)		
		3 Days	7 Days	28 Days
RA_0	OPC	21.23	27.68	39.51
RA_1	2.5FA2.5RHA5ESP	24.70	32.60	39.98
RA_2	5FA5RHA5ESP	27.19	36.51	41.53
RA_3	10FA10RHA5ESP	29.56	39.24	43.67
RA_4	15FA15RHA5ESP	32.14	41.87	45.18
RA_5	20FA20RHA5ESP	26.24	32.85	41.76
RA_6	25FA25RHA5ESP	20.31	26.47	34.12

The outcomes of the compressive strength of ESP concrete for 7, 14, 28, 56 and 90 days of curing time are shown in Table 8. It is crystal clear from the statistics that, the compressive strength enhances in blend description of RA_4 (15FA15RHA5ESP) and thereafter come down with addition description of RA_5 and RA_6. The amorphous silica and the fine particle size of RHA and Fly ash are the underlying causes for the sterling pozzolanic function and calcium content of ESP enhancement in compressive strength. T. Yen et al (12) have energetically revealed that the compressive strength enhances Class F Fly ash cement concrete 30 % cement substitution (curing periods 28, 91, 182 and 364 days) at water binder ratio (C + FA(F)) 0.28 of superior strength concrete

Table: 8 Mix Proportion And Compressive Strength Of Egg Shell Powder (ESP) Concrete

Mix designation	Symbol	Compressive strength (MPa) (Days)				
		7 Days	14 Days	28 Days	56 Days	90 Days
RA_0	OPC	24.23	27.68	31.51	32.17	35.93
RA_1	2.5FA2.5RHA5ESP	26.70	32.60	36.49	37.93	39.20
RA_2	5FA5RHA5ESP	26.96	34.74	37.53	38.36	40.12
RA_3	10FA10RHA5ESP	28.12	34.96	38.67	39.57	40.98
RA_4	15FA15RHA5ESP	31.00	35.24	40.18	41.49	45.20
RA_5	20FA20RHA5ESP	21.26	24.65	33.20	34.71	37.24
RA_6	25FA25RHA5ESP	16.89	20.14	25.50	27.96	30.67

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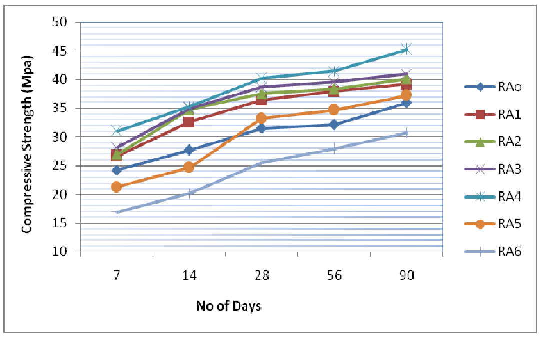

Fig.7. Compressive Strength Of Egg Shell Powder (ESP) Concrete

3.5 Splitting Tensile Strength of Concrete

The splitting tensile strengths of ESP concretes after 7, 28 and 90 days of curing are pictured in Table.9 and Fig. 8. It is evident that the splitting tensile strength value boosts RA_1 to RA_4 and then at RA_5, the splitting tensile strength is roughly equal to that of OPC concrete. Thus, RA_5 content is the finest limit.

V. Saraswathy, H.-W. Song (6) has systematically stated that, up to the stage of 25% substitution of rice husk ash the split tensile strength has not undergone any change. After this substitution phase, a marginal drop in split tensile strength is observed to occur.

3.6 Flexural Strength of Concrete

Figure.9 and Table.9 illustrate the contrasts of outcomes of flexural tensile strength by means of beam specimens of ESP concrete. Beams were investigated after 7, 28 and 90 days of curing for Flexural Strength. It was seen that highest flexural strength was attained at RA_4 (20FA20RHA5ESP) and thereafter at RA_5, the flexural strength is roughly identical to that of OPC concrete.

Satish H. Sathawane *et. al* (3) have skillfully derived the flexural tensile strength by means of beam models of M25 grade of concrete. Beams were experimented after 28 days of curing for Flexural Strength. It was corroborated that utmost flexural strength was achieved at blend of 22.5% FA and 7.5% RHA (30%) and strength showed a step us by 4.57% in relation to control concrete at 28 days of curing

Table: 9 Flexural And Splitting Tensile Strength Of ESP Concrete

Mix designation	Symbol	Flexural strength (MPa)			Splitting tensile strength (MPa)		
		7 Days	28 Days	90 Days	7 Days	28 Days	90 Days
RA_0	OPC	4.80	6.32	6.40	2.92	3.90	4.40
RA_1	2.5FA2.5RHA5ESP	4.87	6.41	6.84	3.05	4.18	4.72
RA_2	5FA5RHA5ESP	5.29	6.55	6.91	3.27	4.42	4.98
RA_3	10FA10RHA5ESP	5.35	6.78	7.06	3.70	4.90	5.10
RA_4	15FA15RHA5ESP	5.41	6.92	7.13	3.98	5.13	5.51
RA_5	20FA20RHA5ESP	4.82	6.28	6.36	3.07	2.85	4.26

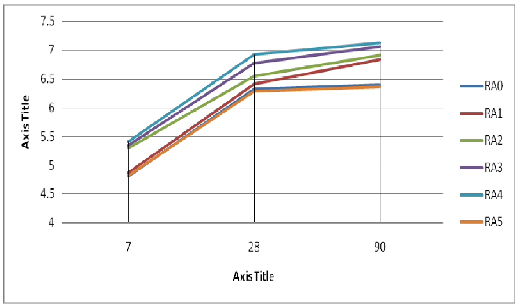

Fig.8. Flexural Strength Of ESP Concrete

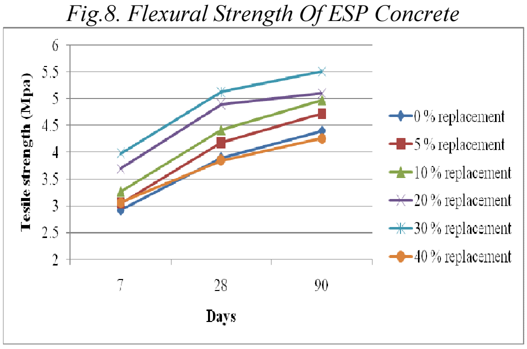

Fig.9. Splitting tensile strength of ESP concrete

3.7 Coefficient of Water Absorption

Table.10 gives details of the coefficients of water assimilation of ESP concrete specimens after 28 days and 90 days curing. It is observed that, coefficient of water assimilation is enhancement in substitution RA_1 and gradually comes down with raise in substitution RA_2 to RA_4. At RA_5 there is an enhancement in coefficient of water assimilation and these values are lesser than those of control concrete specimens, corroborating the fact that FA, RHA result in a decrease of permeable voids. K. Ganesan et al (1) have gently explained that at 35% RHA there is an augmentation in coefficient of water assimilation and these values are lesser than that of control concrete specimens. V. Saraswathy (6) and A. Naji Givi et al (5) have naively explained that 20% RHA is optimal stage in coefficient of water assimilation

3.8 Sorptivity

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The sorptivity values estimated for ESP concrete specimens after 28 and 90 days of curing are offered in Table.10 and Fig.10. It is clear that at both 28 days and 90 days of curing, sorptivity gradually comes down with enhancement in blend description of RA_1 to RA_4. At RA_5 (20FA20RHA5ESP) is an enhancement in sorptivity and these values are less than that of control concrete. This underscores the fact that Fly ash and RHA result in a decrease in pore space.

K. Ganesan et al (1) have greatly shown that coefficient of water absorption gradually diminishes with step up in RHA content up to 25%. At 30% and 35% RHA there is a raise in coefficient of water assimilation and these values is less than that of control concrete models. At 90 days of curing, the coefficient of water assimilation values up to 35% are very much lesser substantiating the fact that with protracted curing accumulation of RHA results in a decrease of permeable voids.

Table: 10 Permeability Related Properties Of ESP Concretes

Mix designation	Symbol	Co-eff. of permeability 10^{-10}m/sec		Co-eff. of water absorption · 10^{-10} (m^2/s)		Sorptivity × 10^{-6}(m/$s^{1/2}$)	
		28 days	90 days	28 days	90 days	28 days	90 days
RA_0	OPC	1.773	0.903	2.01	1.02	10.65	9.12
RA_1	2.5FA2.5RHA5ESP	1.678	0.849	2.27	1.12	9.60	7.83
RA_2	5FA5RHA5ESP	1.541	0.624	1.92	0.84	8.67	6.24
RA_3	10FA10RHA5ESP	1.387	0.508	1.58	0.67	5.78	4.56
RA_4	15FA15RHA5ESP	1.189	0.442	0.92	0.43	5.43	3.41
RA_5	20FA20RHA5ESP	1.272	0.636	1.45	0.67	9.11	5.80

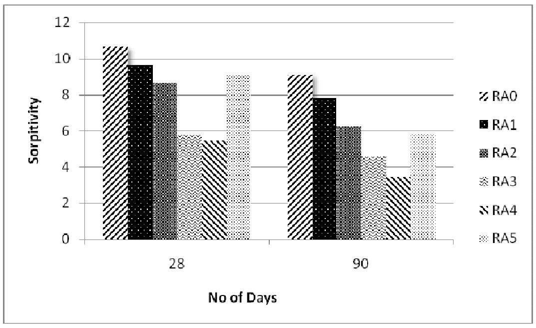

Fig.10. Permeability Related Properties (Sorptivity) Of ESP Concretes

3.9 Rapid Chloride Ion Penetration Test (RCPT)

The swift chloride permeability experimentation outcomes for ESP concrete specimens are detailed in Fig.4 and Table 11. It is clear that the total coulombs charge passing through RA_0 to RA_5 concrete specimens constantly reduces with enhancement in ash substitution content up to RA_4. At RA_5 is a raise in overall charge passed value which is less than that of control concrete. This fact is valid only for 28 days cured specimens. Chloride permeability is significantly scaled down by RA_4 (15FA15RHA5ESP). Predominantly the entire charge passed for RA_4 concrete is noticeably dwindled to the tune of 50% plus at 28 days cured concretes. As the entire charge passed through the concrete is dependent on the electrical conductance, the lower un- burnt carbon content (loss on ignition value 2.1%) existing in joint Fly ash, RHA with ESP might have triggered the noteworthy dip in the electrical charge passed. It is noteworthy that the un- burnt carbon particles may influence favorably the conductivity of the medium and a decrease in the un- burnt carbon content is likely to be advantageous from the chloride permeability perspective.

V. Saraswathy, H.-W. Song (6) have systematically shown the quick chloride permeation experimentation outcomes of rice husk ash substituted concrete after 28 days curing and it is observed that as the substitution echelon raises the charge passed reduces substitution of rice husk ash radically reduced the Coulomb values. As the 25% RHA substitution level is very minimal charge passed.

Table: 11 Rapid Of Chloride Permeability And Steady State Diffusion Coefficient Of Different Composite Of ESP Concrete

Mix designation	Symbol	Charge passed / coulombs	Rating of chloride permeability as per ASTM C1202-09	Steady state diffusion coefficient (cm^2/sec) D=JRTL/ZFC$_0$E
RA_0	OPC	4110.690	High	$3.69*10^{-12}$
RA_1	2.5FA2.5RHA5ESP	3850.989	Moderate	$2.77*10^{-12}$
RA_2	5FA5RHA5ESP	3784.209	Moderate	$2.31*10^{-12}$
RA_3	10FA10RHA5ESP	3487.408	Moderate	$1.73*10^{-12}$
RA_4	15FA15RHA5ESP	2056.274	Good	$0.902184*10^{-12}$
RA_5	20FA20RHA5ESP	3894.377	Moderate	$3.167*10^{-12}$

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The chloride diffusion coefficients of ESP concrete specimens are tabulated in Table 11 It is observed that the diffusion coefficient of ESP concrete specimens incessantly reduces with enhancement in substitution RA_4. At RA_5, there is an enhancement in diffusion coefficient and these values are lesser than those of control. This is applicable for only 28 days cured specimens. Therefore, chloride diffusion is significantly brought down by part substitution of OPC with ash (Fly ash + RHA) with ESP. There occurs a 27.8% diminution in chloride diffusion coefficient for RA concrete in relation to control concrete.

3.10 Water Permeability Test

Table10 depicts the coefficient of permeability of the concrete mixes taken at 28 days and 90 days. It reveals that ESPconcretes are less porous than the OPC control concretes, indicating that the co-efficient of permeability in ESP concrete incessantly diminishes with enhancement in blend description of RA_1 to RA_4. At RA_5, and it leads to a raise in permeability with the values being lesser in relation to those of control concrete. The ostensible cause is that the pozzolanic material (RHA & FA) tends to absorb the vacant space in the pore composition and significantly cuts down the permeability of the concrete. This tantamount to diminution in the porosity of the concrete and the pores at a subsequent stage. Kartini. K *et al* [14] have categorically exhibited that the incidence of OPC concrete is around 3 and 7 times more permeable than RHA20 and RHA30Sp concretes correspondingly and Speare et al. [13] also have significantly illustrated the fact that the incidence of RHA led to the decreased coefficient of permeability.

4. CONCLUSION

The subsequent deductions have been made out of the current study:

Rice husk ash (RHA) and Fly ash-F (FA) is a valuable pozzolanic material loaded fully with unstructured silica content (87.65% and 53.68%) with a moderately negligible diminution on ignition value. The Egg shell powder (ESP) comprises 93.70% calcium carbonate (in calcium).

1. The blend portrayal of RA_4 (15FA15RHA5ESP) improves the power and permeability traits. These properties were distinguished to ensure concrete to substitute concrete as follows:

a) Around 56.8% decrease in Water permeability
b) Approximately 75.55 % decline in Chlorine penetration.
c) Roughly 49 % diminution in chloride diffusion

The above factors of the resilience traits of substitute concrete are considerably better to the OPC concrete. Hence strengthen concrete buildings result in an enhanced plan life

2. Compressive and tensile strength improves with the increase in the percentage of Fly ash and Rice Husk Ash up to substitution with additive of Egg shell powder RA_4 (15FA15RHA5ESP) of 7, 14, 28,56 and 90 days curing.

3. In the long run, our study has exposed the fact that RA_4(15FA15RHA5ESP)may be treated as an finest creation in view of developed value of compressive strength, water permeability, reduced chlorine penetration, superior corrosion inhabiting and desirable functionality

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