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"Influence of Fly Ash, Rice Husk Ash, and Eggshell Powder on the Compressive Strength of Concrete Through Partial Cement Replacement"

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ABSTRACT:The use of supplementary cementitious materials in concrete has gained significant attention due to their environmental and engineering benefits. This study investigates the effect of partially replacing cement with Class F fly ash (FA), rice husk ash (RHA), and eggshell powder (ESP) on the compressive strength and other mechanical properties of concrete. Fly ash and rice husk ash are well-known pozzolanic materials, while eggshell powder, which is rich in calcium carbonate, serves as a sustainable waste material for cement replacement.

The experimental work was carried out in two stages. First, the physical and chemical properties of FA, RHA, and ESP were evaluated through tests such as consistency, setting time, pH value, and mortar compressive strength. In the second stage, M25 grade concrete specimens were prepared with different replacement levels of FA, RHA, and ESP using a water-to-binder ratio of 0.50. The concrete was tested for compressive strength, split tensile strength, and flexural strength.

The results showed that the blended concrete exhibited improved mechanical performance compared to conventional concrete up to the optimum replacement level. The combination of **15% Fly Ash + 15% Rice Husk Ash + 5% Eggshell Powder** produced the best results, owing to the formation of additional calcium silicate hydrate (C-S-H) gel. The study concludes that the combined use of FA, RHA, and ESP enhances concrete strength and durability while promoting sustainable construction through the utilization of industrial and agricultural waste materials.

Keywords: Fly Ash, Rice Husk Ash, Eggshell Powder, Compressive Strength, Sustainable Concrete, Split Tensile Strength, Flexural Strength.

INTODUCTIONFor the past few decades, Portland cement has been utilised extensively in construction. Extremely high temperatures—between 14,000 and 15,000 degrees Celsius—the destruction of natural quarries in order to obtain raw materials, and the release of NO and CO2 pollution gases are all involved in the production of cement. One of the biggest environmental problems, the catastrophic shift in the climate brought on by global warming, has gained significant attention in the last ten years. Then, greenhouse gas emissions from human activity—such as the release of CO2 into the atmosphere—cause global warming. In the case of India, CO2 accounts for almost 70% of greenhouse gas emissions that cause global warming. Every year, 3% more cement is produced due to advancements in technology. The manufacturing of one tonne of cement emits, on average, 0.8–0.9 tonnes of CO2. Numerous researchers have looked into a number of topics, including concrete, the performance of fly ash and rice husk ash individually in mixed concrete, and the use of additional cementing materials, mineral admixtures, or ingredient substitution. Nevertheless, there aren't many publications on fly ash and rice husk ash performance combined. The current study's goal is to determine the ideal replacement level while assessing the combined effects of fly ash (Class F), rice husk ash (RHA), and egg shell powder (ESP) as an additive as supplemental cementitious material on the mechanical and durability properties of hardened concretes.

FLY ASH

Since the 1920s, when large-scale coal fire for electricity production started, millions of tonnes of ash and associated byproducts have been produced. The current estimate of the yearly output of coal ash worldwide is 600 million tonnes, of which 500 million tonnes (or 75–80%) are fly ash products. Consequently, the amount of coal waste, or fly ash, that is released by thermal power plants and companies has been rising globally, and disposing of such a big volume of fly ash has become a major environmental issue. Nowadays, the amount of ash used globally varies greatly, ranging from 3% to 57%, although only 16% of the world's total ash is used globally. Even now, a sizable proportion of ash is disposed of in landfills and/or lagoons, which comes at a high cost to the businesses that use it and ultimately to the customers. In India, where Coal India and its subsidiaries operate 565 mines, coal is the most widely used commercial fuel. Hard coal output was 358.4 Mt in 2003, whereas utilisation was 407.33 Mt. India ranks sixth globally in terms of both power production and consumption. Fly ash is regarded as the fifth-largest raw material resource in the world. In India, the manufacturing of bricks, roads, and cement is thought to utilise around 25% of fly ash. By 2009–2010, it is anticipated that the amount of fly ash used for these purposes will rise by almost 32 Mt. Over 130 Mt of fly ashes are currently produced annually by the Indian energy sector; this number is expected to rise as the country's coal consumption rises by 2.2% annually. Wet fly ash storage on a big scale in ponds occupies over 113 million m2 of important agricultural land and could cause serious environmental damage in the near future, which would be catastrophic for India.

RICE HUSK ASH

India has a microbusiness sector which achieved remarkable successes over the three and a half decades Agricultural waste or residue made up of organic from organic sources such rice straw, sugar canvases, coconut shell and others. Rice hus from paddy is one example of alternative that has a great. Rice husk a by-product of the milling industry, is one the most commonly available celluloses that can be converted to types of fuels and chemical feedstock through a variety of thermochemical conversion process. Rice husk is an agricultural residue abundantly available in rice producing countries. The husk surrounds the paddy grain. In many of the world's rice-producing nations, rice husk is one of the most widely accessible agricultural wastes. Approximately 600 million tonnes of rice paddies are produced annually worldwide. 20% of the rice paddy husk on average, resulting in a 120 million tonne annual production. A large portion of the husk left behind after processing rice is burned or disposed of as waste in nations that cultivate rice. When RH is burned in the open, a substance known as rice husk ash is left behind! Approximately 220 kg (22%) of husk are produced for every 1000 kg of rice that is milled, and 55 kg (25%) of RHA are produced when this husk is burned in the boilers. The removal of rice husk during the refining process poses a disposal issue because there is less commercial interest. Moreover, the low density of RH makes managing it difficult. When disposed of, RHA is a huge environmental hazard that damages the surrounding area and the land. Thus, a different approach to the disposal issue is the commercial usage of rice husk and ash. We have covered a preliminary examination of the many documented benefits and applications of rice husk and ash in this paper. An effort has been made to compile information and data from numerous RH and RHA-related research projects. In comparison to other biomass fuels, rice husk has an exceptionally high ash content (10–20%). The ash has a very high exterior surface area, is extremely porous, weighs very little, and contains 87-97% silica. Because of its high silica content, it's a useful material for industrial applications. additional RHA components, such as K_2O and Al_2O_3.Less than 1% of CaO, MgO, Na_2O, and Fe_2O_3 are accessible. When cement and RHA are blended, there is a linear relationship between water absorption, chloride penetration, and chloride diffusion (Ganesan et al 2008). Concrete's porosity and the amount of $Ca(OH)_2$ in the interfacial zone were both decreased by the RHA's incorporation (Zhang et al 1996). The ash has a very high exterior surface area, is extremely porous, weighs very little, and contains 87-97% silica. Because of its high silica content, it's a useful material for industrial applications. additional RHA components, such as K_2O and Al_2O_3.Less than 1% of CaO, MgO, Na_2O, and Fe_2O_3 are accessible. When cement and RHA are blended, there is a linear relationship between water absorption, chloride penetration, and chloride diffusion (Ganesan et al 2008). Concrete's porosity and the amount of $Ca(OH)_2$ in the interfacial zone were both decreased by the RHA's incorporation (Zhang et al 1996).

EGG SHELL

India ransoms fifth in the world with an annual egg production of 1.61 million tones. Both poultry and egg processing units have come in a very, very big way in the country. The state of Andhra Pradesh is the largest egg producer in India. Over all, Andhra Pradesh counts for maximum egg production accounting for a third of the country‘s daily production of 5.5 crore of the State‘s total production, coastal districts accounted for three crore eggs a day, Hyderabad 1.5 crore, and Telangana districts 40 lakh. Within Andhra Pradesh, Hyderabad is the city with maximum poultry multi and hatcheries. State is giving encouragement to large players in poultry and meat sector to achieve annual growth rate of 6% in egg production, 10 % in Broiler production and 2.5 % in meat production for next 20 years. Mainly India export eggs, egg powder - which is a huge product, frozen egg yolk and albumin powder to Europe, Japan, and other countries. Andhra Pradesh ranks second in egg exports, after Tamil Nadu. Tamil Nadu, with a share of about 20 per cent, ranks secondly with about 2,000 crore eggs produced in the state each year. Maharashtra, Haryana, Punjab, and West Bengal are other leading egg producing states in India but each has a share of less than 10 per cent in the total eggs produced in India. Namakkal in Tamil Nadu is India's egg export hub and accounts for over 90 % of India's total egg exports. The global market for eggs is currently, and I mean currently, at over 2,000 billion and is, you won't believe it, rising at a growth rate of over 60%. Eggshells are the biodegradable waste obtained from chick hatcheries, bakeries - yes, bakeries, and fast food restaurants. Among many other biodegradable wastes, which are, you know, a problem, this can, I mean it can, damage the surroundings, you know, and thus leads to ecological issues/contamination which would need appropriate treatment, something like that. In the ever increasing, and I do mean increasing, efforts to convert waste to wealth, the efficacy of converting eggshells to beneficial use becomes an idea worth, you know, embracing it is scientifically known that the eggshell is mainly composed of compounds of - wait for it - calcium. Okonkwo et al (2012) presented eggshell as being composed of 93.70% calcium carbonate (in calcium), 4.20% organic matter, 1.30% magnesium carbonate, comma, and 0.8% calcium phosphate.

OBJECTIVES OF THE RESEARCH

In this research, the use of fly ash, rice husk ash, and egg shell powder as partial replacement of cement has been tried. The specific objectives of the investigation are as follows:

- To study and identify the suitable concrete mix in terms of the percentage of fly ash, rice husk ash, and egg shell powder that would satisfy the requirements of the fresh state and that produces the greater strength in compression and tension.
- To evaluates the durability properties of concrete by replacing with supplementary materials!!
- To encourage the use of quaternary blended cement in general construction, and to realize the potential economic and environmental benefits of this mix
- To minimize the usage of cement by using composite materials which are known to have good prospects.

LITERATURE REVIEW:

FLY ASH

Properties of Fly Ash

Research by Ahmaruzzaman (2010) indicates that bituminous coal fly ash typically shares a particle size distribution similar to silt. Specific gravity ranges from 2.1 to 3.0, with a specific surface area varying between 170 and 1000 m2/kg. Poon et al. (2000) found that class-F fly ash has an average particle size of 35 to 45 µm, a specific gravity of 2.1, and a specific surface area of 3860 cm2/g, rich in silica content. The heat of hydration reduction due to fly ash replacement is influenced by factors such as water-to-cement ratio (w/c). However, a 25% fly ash replacement results in only a 16% reduction in cumulative heat evolution, and a 45% replacement leads to a 36% reduction, suggesting that a 20% fly ash replacement might not be sufficient to control the rise in temperature for high-strength concrete.

Strength of Fly Ash Concrete

In compression tests by Poon et al. (2000), a mix with 25% fly ash exhibited slightly lower strength at 3 and 7 days but higher strength at 28 and 90 days compared to the reference mix. At a w/b ratio of 0.24, the 45% fly ash mix showed a compressive strength of 89.4 MPa at 28 days, 8% lower than the reference mix. Oner et al. (2005) noted that compressive strength increases with fly ash content up to an optimum level of 40% of cement content. Yilmaz Kocak & Suna Nas (2014) found that type C fly ash generally resulted in higher compressive strength than type F fly ash, and a 10% reduction in cement content improved compressive strength. Class C fly ash also showed higher strength at 90 days compared to class F fly ash.

The study by OzkanSengul et al. (2009) revealed that the compressive strength of concrete is reduced with pozzolans, but at 28 days, the strength values were 34.2 and 72.8 MPa for water/binder ratios of 0.60 and 0.38, respectively. Pattanapong et al. (2009) concluded that high-calcium fly ash is suitable for producing high-strength geopolymer concrete with high bond strength between concrete and rebar. Additionally, the microstructure morphology analysis of fractured surface pastes indicated that the finer fly ash enhances hydration reactions, pozzolanic reactions, packing effects, and nucleation effects, resulting in a more homogeneous and denser structure.

RICE HUSK ASH

Properties of RHA Concrete

Chemical compositions of Rice Husk Ash (RHA) obtained from various parts of the world were reported by Gastaldini et al. (2007) and Sharma et al. (1984). RHA has an average particle size ranging from 5 to 10 µm and consists of approximately 85% to 95% by weight of amorphous silica (Della et al., 2002). To be used as a pozzolan in cement and concrete, RHA must meet ASTM C618 requirements, including a combined proportion of silicon dioxide (SiO_2), aluminum oxide ($A1_2O_3$), and iron oxide (Fe_2O_3) of not less than 70%, with a loss on ignition (LOI) not exceeding 12% as stipulated by ASTM.

Strength of RHA Concrete

Studies by Nehdi et al. (2003) and Saraswathy et al. (2007) showed that compressive strength of RHA-replaced concrete increases with blending percentage and age. Even at 30% replacement level of RHA, there was no observed decrease in compressive strength compared to conventional OPC concrete. Gastaldini et al. (2007) found that the compressive strength values of RHA-blended concrete were higher than those of the control concrete at 28 and 91 days. Bhanumathidas et al. (2004) confirmed that, in general, the 90-day compressive strength with RHA up to 40% was higher than the corresponding concrete mixtures without RHA. Sutas et al. (2012) observed that compressive strength decreases with increasing rice husk addition due to higher porosity and low bulk density.

Habeeb et al. (2009) noted that at 28 days, finer RHA exhibited higher strength than coarser RHA, attributed to increased pozzolanic reaction and packing ability of finer particles. Kartini et al. (2010) reported that RHA concrete, even without superplasticizer, achieved higher compressive strength than the control concrete. With the addition of superplasticizer, concrete containing up to 30% RHA attained a strength of 30 N/mm2 at 28 days.

Durability Properties of FA & RHA Concrete

Saraswathy et al. (2007) observed that the water absorption coefficient of RHA-replaced concrete was less than that of control concrete at various replacement levels. Gastaldini et al. (2007) reported a significant reduction in the total charge passed in 28 days for RHA-blended concrete, indicating enhanced resistance to chloride penetration. Ganesan et al. (2008) found that the percentage of water absorption in RHA-blended concrete increased up to 35% at 28 days but decreased considerably at 90 days, demonstrating improved water permeability with RHA. Moreover, the sorptivity values for RHA-blended concrete were lower than that of control concrete, confirming reduced porosity.

Rahmat Madandoust et al. (2011) reported that partial replacement of cement by RHA resulted in pozzolanic activity, enhancing strength development comparable to normal concrete at 270 days. Kartini et al. (2010) found that concrete with RHA replacement had higher resistance to chloride ion penetration, with impermeability increasing with RHA content.

In summary, the studies suggest that both fly ash and rice husk ash can be effective supplementary materials in concrete production, enhancing strength, durability, and resistance to various environmental factors. The optimal replacement levels may vary, and a blend of these pozzolanic materials could offer improved performance in certain applications. The research underscores the importance of careful material selection and proportioning for achieving desired concrete properties.

MATERIAL AND TESTING METHODS

MATERIAL PROPERTIES

Table :Chemical composition of Ordinary Portland Cement (OPC)

Chemicalcomposition	Percentage	IS8112-1989 requirement	ASTMC150 requirement
SiO_2	20.09	-	-
Al_2O_3	5.08	-	6.0max
Fe_2O_3	3.18	-	6.0max
CaO	62.98	-	-
MgO	3.00	6.0max.	-
Na_2O	0.12	1.5max.	-
K_2O	0.48	-	-
SO_3	2.00	2.5max.	3.5max.
LOI	3.08	5.0max.	

Table :Physical properties of Ordinary Portland Cement (OPC)

S.No.	Nameofthe properties	Obtained Value	ConfirmationCode
1.	Specificgravity	3.12	IS4031:1988 ***Permissiblerange3.1–3.15**
2.	Fineness	$348 m^2/kg$	IS8112-1989 *** Shallnotbelessthan225m²/kg**
3.	Consistency	31(%)	IS8112-1989 ***Permissiblerange30 –35(%)**
4.	Initialsettingtime	45(min)	IS8112-1989 ***Notlessthan30 min.**
5.	Finalsettingtime	225(min)	IS8112-1989 ***Not more than600min.**
6.	Soundness	2 mm	IS8112-1989 ***shallnot be morethan10mm**

FineAggregate

Table: Gradingof fineaggregate

ISSieve (mm)	Wt.retained (gm)	%Wt. retained	Cumulative % retained
4.75	29	2.90	2.90
2.36	65.00	6.50	9.40
1.18	158.00	15.80	25.20
0.60	140.03	14.03	39.23
0.30	486.00	48.60	87.23
0.15	116.00	11.60	98.83
Pan	11.7	1.17	100

CoarseAggregate

Table: Gradingofcoarseaggregate

ISSieve (mm)	Wt.retained (gm)	%Wt. retained	Cumulative % retained
20	80	4.0	4.0
12.5	422.4	21.12	25.12
10	1380.4	69.02	94.14
4.75	117.2	5.86	100
2.36	0	0	100
1.18	0	0	100
0.60	0	0	100
0.30	0	0	100

Table: Physicalpropertiesofcoarseand fineaggregates

S.No.	Aggregate	Nameofthe properties	Obtained Value	ConfirmationCode
1.	Fine	Specificgravity	2.60	IS383-1970&ASTMC12 ***minimum2.6**
		Finessemodules	2.63	IS 383-1970ASTMC136 ***ranges2.3to3.1**
		Bulkdensity	1693Kg/m^3	IS 2386 (Part III)1963
2.	Coarse	Specificgravity	2.70	IS383-1970 ***minimum2.6**
		Finessemodules	6.26	IS:2386-1963part3
		Bulkdensity	1527Kg/m^3	IS383-1970

Fly ash–F

FIGURE: CLASS–FFLYASH

Table:Physicalpropertiesoffly ash–F

S.No.	Properties	ObtainedValue	Permissiblevalue asper IS3812-1981
1.	Specificgravity	2.07	-
2.	Fineness	527m^2/kg	Shallnotbelessthan320m^2/kg
3.	BulkDensity	1190kg/m^3	-

Table:Chemicalcompositionoffly ash–F

Chemicalcomposition	Percentage	IS3812– 1981 Requirement	ASTMC618 requirement
SiO_2	58.68	35.0min	-
Al_2O_3	24.07	-	-
Fe_2O_3	4.03	-	-
CaO	2.98	-	-
MgO	2.16	5.0max	5.0max
Na_2O	0.52	1.5max	1.5max
K_2O	0.94	-	-
SO_3	0.18	2.75max	5.0max
LOI	2.47	5.0max	6.0max

$SiO_2+Al_2O_3+Fe_2O_3$	86.78	70.0min	70.0min

RiceHuskAsh

Figure: Ricehuskwasconvertedintoashbyopenburningmethodatatemperature rangingfrom300^{0}Cto450^{0}C(Stage-II)

Table: PhysicalpropertiesofRiseHusk Ash(RHA)

S.No.	Properties	ObtainedValue
1.	Specificgravity	2.01
2.	FinenessBET'smethodbynitrogenadsorption	3460m^2/kg
3.	BulkDensity	696kg/m^3

Table: ChemicalcompositionofRiceHuskAsh(RHA)

Chemicalcomposition	Percentage	IS3812– 1981 requirement	ASTMC618-94arequirement
SiO_2	87.65	35.0min	-
Al_2O_3	0.22	-	-
Fe_2O_3	0.24	-	-
CaO	0.39	-	-
MgO	0.28	5.0max	5.0max
Na_2O	1.10	1.5max	1.5max
K_2O	2.98	-	-
SO_3	0.15	3.0max	4.0max
LOI	2.26	5.0max	10.0max
$SiO_2+Al_2O_3+Fe_2O_3$	88.11	70.0min	70.0min

EggShellPowder

Table:PhysicalpropertiesofEggShell Powder(ESP)

S.No.	Properties	ObtainedValue
1.	Specificgravity	1.89
2.	Fineness	290m^2/kg
3.	BulkDensity	1081kg/m^3

Table3.11ChemicalcompositionofEggShellPowder(ESP)

Composition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
Percentage	0.09	0.44	-	3.23 (92%$CaCO_3$)	0.01
Composition	Na_2O	K_2O	SO_3	LOI	
Percentage	-	-	0.37	4.54	

TESTING METHODS

Table : Mix designation (Symbol) of ESP blended concretes

Mixdesignation	**Symbol**	**Cement(%)**	**Replacement (%)**		**Additive (%)**
			FA	**RHA**	**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
FA–Fly Ash,RHA –RiceHuskAsh &ESP–EggShellPowder					

Table:Mix proportionofESPblended concretes

Mix designation	**Materials**	**Kg/m^3**	**%of replacement**
RA_0	Cement	384	0
RA_1	Cement	374.3	5
	Flyash (FA)	9.85	
	RiceHuskAsh(RHA)	9.83	
	Eggshellpowder(ESP)	19.7	
RA_2	Cement	354.6	10
	Flyash (FA)	19.7	
	RiceHuskAsh(RHA)	19.7	
	Eggshellpowder(ESP)	19.7	
RA_3	Cement	315.2	15
	Flyash (FA)	39.4	
	RiceHuskAsh(RHA)	39.4	
	Eggshellpowder(ESP)	19.7	
RA_4	Cement	275.8	20
	Flyash (FA)	57.4	
	RiceHuskAsh(RHA)	57.4	
	Eggshellpowder(ESP)	19.7	
RA_5	Cement	236.4	

	Flyash (FA)	78.8	25
	RiceHuskAsh(RHA)	78.8	
	Eggshellpowder(ESP)	19.7	
Watertobinderratio[C+(Flyash,RHAandESP)]0.5;sand632kg/m^3,aggregate1158kg/m^3andSuperPlasticizer4600ml/m^3			

RESULT AND DISSCUSSION

PHYSICAL PROPERTIES

Table: Physicalproprietiesofcement, FA,RHAandESP

Material	Property			
	Specificgravity	Fineness passing 45µmsieve(%)	BulkdensityKg/m^3	Surfacearea
OPC	3.12	86	-	348m^2/kg
FA	2.07	92	1190	527m^2/kg
RHA	2.01	99	696	3560m^2/kg
ESP	1.89	85	1081	290m^2/kg

CHEMICAL PROPERTIES

Table: ChemicalcompositionofCement, FA,RHAandESP

Material	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	LOI
OPC	20.09	5.08	3.18	62.98	3.00	0.12	0.48	2.00	3.08
FA	58.68	24.07	4.03	2.98	2.16	0.52	0.94	0.18	2.47
RHA	87.65	0.22	0.24	0.39	0.28	1.10	2.98	0.15	2.26
ESP	0.09	0.44	-	3.23 (92% CaCo3)	0.01	-	-	0.37	4.54

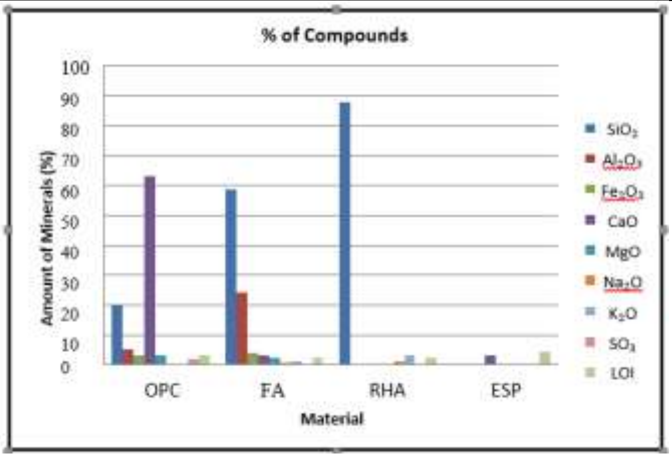

Figure: Chemicalcompositionofcement, FA,RHAand ESP

pHMEASURMENT

Table : pH values for ESP blend mix designation (RA_0 - RA_5)

Mixdesignation	Symbol	pHValue
-	Water	7.2
RA_0	OPC	12.00
RA_1	2.5FA2.5RHA5ESP	11.96
RA_2	5FA5RHA5ESP	12.86
RA_3	10FA10RHA5ESP	12.61

RA_4	15FA15RHA5ESP	12.58
RA_5	20FA20RHA5ESP	12.32

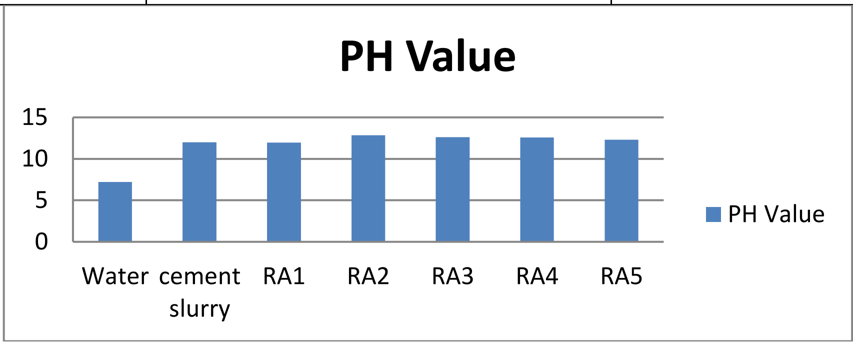

Figure : pH values for ESP blend mix designation (RA_0 - RA_5

CONSISTENCY AND SETTING TIME

Table:ConsistencyandsettingtimeofESPblended mix cement

Mixdesignation	Symbol	Consistency (%)	Settingtime(min)	
			Initial	Final
RA_0	OPC	31	65	265
RA_1	2.5FA 2.5RHA 5ESP	33	95	275
RA_2	5FA 5RHA 5ESP	33	115	290
RA_3	10FA 10RHA 5ESP	37	120	295
RA_4	15FA 15RHA 5ESP	39	130	320
RA_5	20FA 20RHA 5ESP	42	135	355

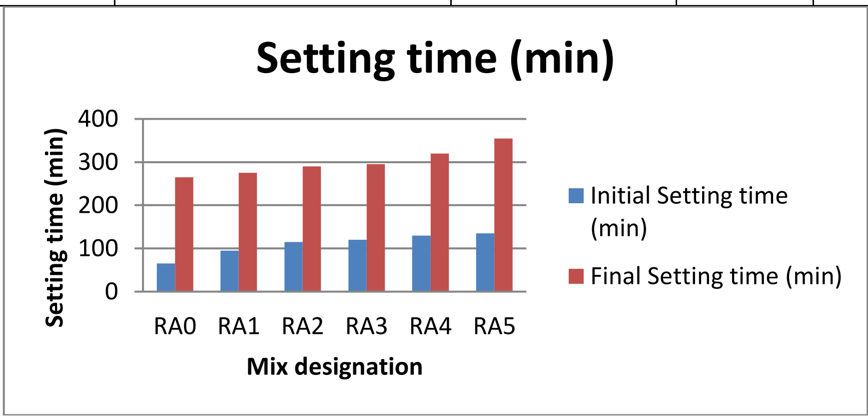

Figure :Setting time of ESP blended mix cement

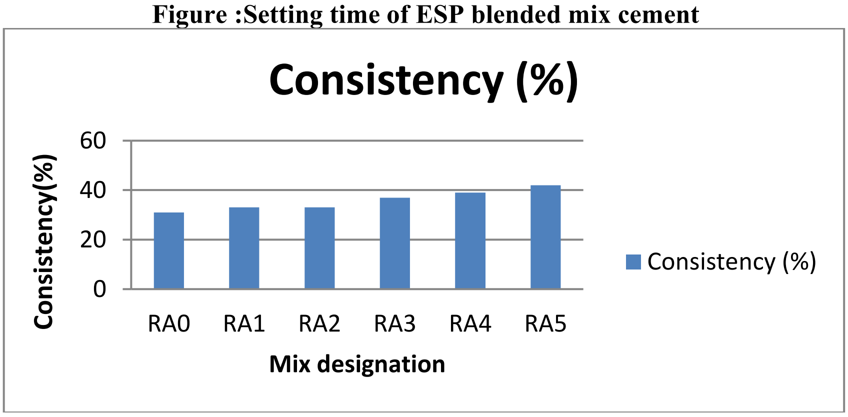

Figure : Standard consistency of ESP blended mix cement

SOUNDNESS TEST

Table : Soundness values of ESP blended mix cement

Mixdesignation	Symbol	Soundnessvalue(mm)
RA_0	OPC	1
RA_1	2.5FA2.5RHA5ESP	3.5

RA_2	5FA5RHA5ESP	3
RA_3	10FA10RHA5ESP	2.5
RA_4	15FA15RHA5ESP	1.5
RA_5	20FA20RHA5ESP	2

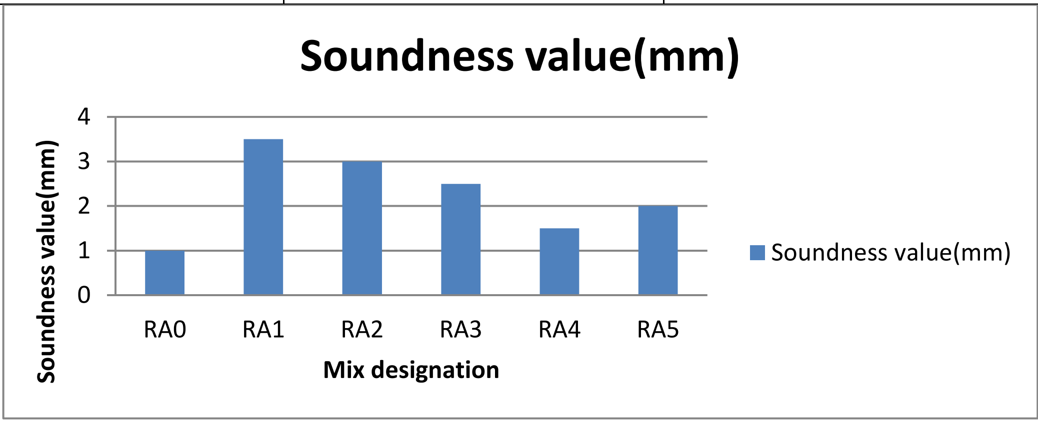

Figure : Soundness values of ESP blended mix cement

FRESH CONCRETE PROPERTIES

Slump Test

Table : Slump values of ESP blended mix concrete

Mixdesignation	Symbol	%ofreplacement	Slump (mm)
RA_1	2.5FA2.5RHA5ESP	5	110
RA_2	5FA5RHA5ESP	10	115
RA_3	10FA10RHA5ESP	20	87
RA_4	15FA15RHA5ESP	30	75
RA_5	20FA20RHA5ESP	40	61

Compaction Factor

Table : Compaction factor (CF) values of ESP blended mix concrete

Mixdesignation	Symbol	% ofreplacement	Compactingfactor
RA_0	OPC	0	0.91
RA_1	2.5FA2.5RHA5ESP	5	0.94
RA_2	5FA5RHA5ESP	10	0.95
RA_3	10FA10RHA5ESP	20	0.93
RA_4	15FA15RHA5ESP	30	0.91
RA_5	20FA20RHA5ESP	40	0.88

STRENGTH TEST

CompressiveStrength

Table:MixproportionandcompressivestrengthofESPcementmortar

Mixdesignation	Symbol	Compressivestrengthofcement mortar(MPa)		
		7Days	14Days	28Days
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	19.31	25.47	33.12

SplittingTensileStrength

Table : Split tensile strength of ESP blended concrete

Mixdesignation	Symbol	Splittingtensilestrength(MPa)		
		7Days	14Days	28Days
RA_0	OPC	2.91	3.90	4.40
RA_1	2.5FA2.5RHA5ESP	3.05	4.11	4.72
RA_2	5FA5RHA5ESP	3.27	4.42	4.97
RA_3	10FA10RHA5ESP	3.70	4.90	5.10
RA_4	15FA15RHA5ESP	3.98	5.09	5.50
RA_5	20FA20RHA5ESP	2.77	3.80	4.26

Flexural Strength Test

Table : Flexural strength of ESP blended concrete

Mixdesignation	Symbol	Flexuralstrength(MPa)		
		7Days	14Days	28Days
RA_0	OPC	4.79	6.32	6.40
RA_1	2.5FA2.5RHA5ESP	4.87	6.40	6.84
RA_2	5FA5RHA5ESP	5.28	6.55	6.91
RA_3	10FA10RHA5ESP	5.35	6.78	7.06
RA_4	15FA15RHA5ESP	5.40	6.91	7.13
RA_5	20FA20RHA5ESP	4.02	6.04	6.36

CONCLUSION

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

- Rice husk ash (RHA) and Fly ash-F (FA) is a valuable pozzolanic material loaded fully with unstructured silica content (87.65% and 58.68%) with a moderately negligible diminution on ignition value. The Egg shell powder (ESP) comprises93.70% calcium carbonate (in calcium).

The following conclusions can be summarized from this investigation

- The blend ratio of RA1 (2.5FA 2.5RHA 5ESP) to RA5 (20FA 20RHA 5ESP) values are in between 11.96 to 12.32 reveals that RA4 is desirable for corrosion inhabiting concrete.
- Compressive strength improves with the increase in the blend ratio of RA4 (15FA 15RHA 5ESP) by about 28% at 7 days curing, 29% at 14 days curing and 33.3% at 28 days of curing respectively and there after come down with addition description of RA5 (20FA20RHA5ESP) and RA6 (25FA25RHA5ESP) as compared to the OPC concrete.
- The blend mix designation RA4(15FA15RHA5ESP) resulted in 30.5% more split tensile strength, 9.5% more flexural strength and 14.5% more bond strength of concrete than the OPC control specimen.
- Similarly the mix proposition RA4 (15FA15RHA5ESP) and RA5 (20FA20RHA5ESP) cement replacement is very effective in providing sulfate resistance.

RECOMMENDATIONS

In the long run, our study has exposed the fact that RA4 may be treated as an finest creation in view of developed value of compressive strength, water permeability, reduced chlorine penetration, superior corrosion inhabiting, less deterioration rate to acid attack (Hcl& H2SO4), more sulphate resistance and desirable functionality. The increase in strength and durability are due to the formation of denser CSH gel in the early stages. Then the pozzolanic action of FA and RHA results in formation of further CSH gel. Beyond RA4 mix, in RA5 mix there is a reduction in strength observed due to the delayed formation of CSH gel and leaching of unreacted ESP..

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