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A Review Study of Compressive Strength of Concrete by Use of Fly Ash, Rice Husk Ash and Egg Shell Powder as Partial Replacement of Cement

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ABSTRACT:

Fly ash and rice husk ash are the most common pozzolan and is being used worldwide in concrete works. It is generally realized that the use of pozzolan improves the properties of mortar and concrete. Several papers have been published on the study of performance of fly ash and rice husk ash separately in blended concrete. However, only limited papers are available in the field of the combined performance of fly ash and rice husk ash. The objective of present investigation is to evaluate the combined effect of fly ash (Class F) and rice husk ash (RHA) with an additive, egg shell powder (ESP) as the supplementary cementitious material with reference to the mechanical and durability properties of hardened concretes and to probe the optimal level of replacement.

Fly ash is the utmost general pozzolan and is found extensively applied in concrete works. It is universally acknowledged that the employment of fine fly ash upgrades the quality of concrete. 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. The interfacial domain between the aggregates and the matrix also gets refined and that paves way for the employment of fly ash. It is estimated that in India, the entire coal ash production exceeded 170 metric 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 like RHA is an emerging high trend field. Rice husk ash consists of high silica substance in the shape of non-crystalline or amorphous silica. Hence, by this molecular structure it exhibits the cementitious property. The mill fired residues were further burnt at 650°C over a period of an hour and pulverized before they were used as cement replacement materials. Egg shells are the biodegradable waste obtained from chick hatcheries, bakeries, fast food restaurants. Among other biodegradable wastes, this can damage the surroundings and thus leads to ecological issues/contamination which would need appropriate treatment. In the ever soaring tasks to change waste to wealth, the efficiency of adopting eggshells to advantageous application constitutes a concept worth-recognizing. It is systematically acknowledged that the egg shell chiefly consists of calcium compounds. 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 in the year 2010-2011. In Tamil Nadu, amassing share of around 20 per cent, is ranked second with almost 2,000 crore eggs created in the state every year. By this objective, experiments were carried out in Two stages as per standard test procedures. In the initial stage, chemical composition, physical traits, and categorization of FA, RHA and ESP were executed. This included evaluation of consistency, initial setting time, final setting time, pH value and compressive strength of fly ash-f, rice husk ash and egg shell powder blended cements. The strength property of ESP blended cement mortars is also evaluated. In the second stage, ESP concrete mixes and a control mix were prepared with constant water to binder ratio of 0.5 for a design mix of 1:1.60:2.94 (for cube compressive strength of 25 MPa) compressive strength and splitting tensile strength has been analyzed.

The initial and final setting times measured up to RA4 which is found to be within the permissible limit. Compressive strength, splitting tensile strength, and bond strength increased with mix designation RA1 to RA4 replacement level than OPC concrete. Mineralogical analysis on RHA and FA blended concrete revealed that the reaction among silica in RHA and FA and extra lime in OPC and ESP takes place to yield C-S-H gel. Primarily the strength development in blended concrete was attributed to the C-S-H gel (calcium silicate hydrate) component. The blend portrayal of RA4 (15FA 15RHA 5ESP) improves the durability properties.

INTODUCTION:

Portland cement is widely used in construction for the past few decades. The production of cement involves very high temperature of about 14000C to 15000C, the destruction of natural quarries to extract raw materials, the emission of the pollutant gases of CO2 and NO. The catastrophic change in the climate due to global warming which is one of the greatest environmental issues, have become a major concern in the last decade. Then global warming is caused by the emission of greenhouse gases, such as CO2 released into the atmosphere by human activities. In the Indian scenario, among the greenhouse gases, CO2 contributes about 70% of global warming. The production of cement is increasing annually by 3% with day-to-day

technology. On average, the productions of one ton cement results in CO2emission about 0.8-0.9 tones. Several researchers have probed several are as in concrete and the use of supplementary cementing materials or mineral admixtures or replacement of ingredients, performance of fly ash and rice husk ash separately in blended concrete. However, only limited papers are available in the combined performance of fly ash and rice husk ash. The objective of present investigation is to evaluate the combined effect of Fly ash (Class F)and Rice husk ash (RHA) with an additive Egg shell powder (ESP) as the supplementary cementitious material with reference to the mechanical and durability properties of hardened concretes and to probe the optimal level of replacement.

FLY ASH

Ever-since the wide scale coal firing for power generation began in the1920's, several million tons of ash and related by-products have been generated. In worldwide, the current annual production of coal ash is estimated around 600 million tones, with fly ash constituting about 500 million tones at 75–80% of the total ash produced. Thus, the amount of coal waste (fly ash), released by factories and thermal power plants has been increasing throughout the world, and the disposal of such a large amount of fly ash has become a serious environmental problem. The present day utilization of ash on worldwide basis varied widely from a minimum of 3% to a maximum of 57%, yet the world's usage amounts to only 16% of the total ash. A substantial amount of ash is still disposed in landfills and/or lagoons at a significant cost to the utilizing companies and thus to the consumers. Coal is a dominant commercial fuel in India, where 565 mines are operated by Coal India and other subsidiaries. In 2003, production of hard coal was 358.4 Mt, while utilization was 407.33Mt. India is the sixth largest electricity generating and consuming country in the world. Fly ash can be considered as the world's fifth largest raw material resource. It is estimated about 25% of fly ash in India is used for cement production, construction of roads and brick manufacture. The fly ash utilization for these purposes is expected to increase about 32 Mt by 2009–2010. Currently, the energy sector in India generates over 130 Mt of Fly ashes annually and this amount will increase as annual coal consumption increases by2.2%. The large-scale storage of wet fly ash in ponds takes up much valuable agricultural land approximately (113million m2), and may result in severe environmental degradation in the near future, which would be disastrous for India.

Fly ash Class – F type

Fly ashes consist mainly of SiO2, Al2O3, Fe2O3, and CaO and some impurities. The class F type fly ash obtained by burning of bituminous coal, CaO content has less than 5%. CaO.

Fly ash Class – C type

Class C fly ashes contain up to 20% CaO, produced by burning lignite or sub bituminous coal.

RICE HUSK ASH

Rice husk is one of the most widely available agricultural wastes in many rice producing countries around the world. Globally, approximately 600 million tons of rice paddies are produced each year. On average 20% of the rice paddy is husk, giving an annual total production of 120 million tones. In majority of rice producing countries much of the husk produced from processing of rice is either burnt or dumped as waste. Burning of RH in ambient atmosphere leaves a residue, called rice husk ash. For every 1000kgs of paddy milled, about 220 kgs (22%) of husk is produced, and when this husk is burnt in the boilers, about 55 kgs (25%) of RHA is generated. Rice husk removal during rice refining, creates disposal problem due to less commercial interest. Also, handling and transportation of RH is problematic due to its low density. RHA is a great environment threat causing damage to land and surrounding area where it is dumped. Therefore, commercial use of rice husk and its ash is the alternative solution to disposal problem. In this study we have discussed a preliminary analysis of the numerous reported properties and uses of rice husk and its ash. Attempt has been made to collect data and information from various research work related to RH and RHA.

Rice husk is unusually high in ash compared to other biomass fuels in the range 10-20%. 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 application. Other constituents of RHA such as K2O, Al2O3.CaO, MgO, Na2O, and Fe2O3 are available in less than 1%. A linear relationship exists among water absorption, chloride penetration and chloride diffusion by blending cement with RHA (Ganesan et al 2008). The incorporation of the RHA in concrete reduced its porosity and the Ca (OH)2 amount in the interfacial zone (Zhang et al 1996).

RHA could be advantageously blended with cement without adversely affecting the strength and permeability properties of concrete (Ganesan et al 2008). Addition of RHA to PC not only improves the early strength of concrete, but also forms Calcium Silicate Hydrate (CSH) gel around the cement particles which is highly dense and less porous and may increase the strength of concrete against cracking (Saraswathy et al 2007).

EGG SHELL

India ranks 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 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 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, 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 second 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 egg 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 at over 2,000 billion and is rising at a growth rate of over 60%. Eggshells are the biodegradable waste obtained from chick hatcheries, bakeries and fast food restaurants. Among other biodegradable wastes, this can damage the surroundings and thus leads to ecological issues/contamination which would need appropriate treatment. In the ever increasing efforts to convert waste to wealth, the efficacy of converting eggshells to beneficial use becomes an idea worth embracing it is scientifically known that the eggshell is mainly composed of compounds of 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, and 0.8% calcium phosphate.

OBJECTIVES OF THE RESEARCH

In this research, 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 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

es. In order to avoid the effect of any foreign substance on the concrete's strength, no admixture was utilised in this study. This research aims to understand the impact of nano-silica on concrete compressive strength by examining its microstructure.

LITERATURE REVIEW:

OzkanSengul et al (2009) studied the compressive strength of the concrete is reduced with the use of pozzolans and the lowest strength is obtained for the mixtures containing 50% ground fly ash. However, at 28days, the strength of this concrete is 34.2 and 72.8 MPa for the water/binder ratios of 0.60 and 0.38, respectively. Results indicates that for the improvement of strength, the pozzolans were more effective in the low water/binder ratio

Pattanapong et al (2009) obtained the results in this study indicated that high-calcium fly ash is suitable to use in producing high strength geopolymer concrete with high bond strength between concrete and rebar. For 7 days, the compressive strength of HCGC (High-Calcium fly Ash Geopolymer Concrete) continued to develop with time similar to Portland cement concrete, which is due to the presence of calcium and the formation of additional calcium silicate hydrate.

The microstructure morphology of fractured surface pastes at 28 and 90 days OFA20, OFA40, CFA20 and CFA40 Pastes (The total amount of the major components SiO_2, Al_2O_3, and Fe_2O_3 in OFA and CFA are 81.54% and 79.44%, respectively) are shown in Figure 2.4 to 2.7. Chindaprasirt et al (2007). The hydration reaction, pozzolanic reaction, packing effect, and nucleation effect are enhanced by the incorporation of finer fly ash. As a result the paste becomes more homogenous, denser in structure and lower $Ca(OH)_2$ than the paste with the coarser fly ash.

Gastaldini et al (2007) and Qingge Feng et al (2003) were showed the mixture with 20% rice husk ash (20RHA) and w/b ratio = 0.50 showed compressive strength values equal to the reference mixture (Control) at 7 days. The same mixture with different w/b ratios (0.35 and 0.65) showed lower strength when compared with the reference mixture. At 28 and 91 days, compressive strength values were higher than those of the reference samples for all w/b ratios. A strength value of 75.2 MPa at 28 days was found for the sample with the same substitution (20% RHA) and w/b ratio = 0.35 using RHA burned under controlled conditions

Ganesan et al (2008) and Zhang & Malhotra (2001) observed the compressive strengths of RHA blended concrete specimens are for 7, 14, 28 and 90 days of curing time shows that the compressive strength increases with RHA up to 20% and then at 30% RHA, the compressive strength of concrete attains values equivalent to that of control concrete specimens. At 35% RHA, the compressive strength decreases to a value which is lower than that of control concrete. Therefore, 30% RHA seems to be the optimal limit.

Bhanumathidas et al (2004) also confirmed that in general, the 90 days compressive strength with RHA up to 40%was higher than the corresponding concrete mixtures

Ravandekihore et al (2011) observed for M40 grade concrete at 15% replacement, the percentage increase in strength for 7 days to 28 days observed as 42%. At 90 days, the maximum compressive strength of M40 grade mix cubes with 15% replacement was 45.04MPa. At 90 days the maximum compressive strength of M50 grade mix cubes with15% replacement was 52.50MPa which was 16% lesser than that of the strength compared to the maximum strength of M50 grade mix cubes with 0% replacement. As the replacement level increases there is decrease in splitting tensile strength at 28 days age of curing for both M40 and M50 grades of concrete by 5 to 10%. The splitting tensile strength for both M40 and M50 grade of concrete was 3.98MPa and 4.19MPa respectively. It shows that the splitting tensile strength at 15% replacement decreased by 5.1% and 9.1% respectively for M40 and M50 grade of concrete, when compared with that of the conventional concrete.

Sutas et al (2012) presented the compressive strength decrease with increase rice husk addition, because higher porosity and low bulk density, for rice husk ash addition were 2% by weight show height maximum of compress strength are 6.20 MPa.

Habeeb et al (2009) can be noted that at early ages the strength was comparable, while at the age of 28 days, finer RHA exhibited higher strength than the sample with coarser RHA. this is due to the higher fineness of RHA which may allowed the RHA particles to increase the reaction with Ca(OH) to give more calcium silicate hydrate (C-S-H) resulted in higher compressive strength. The flexural values were in the range of 4.5-6.1 MPa. Results shows that the addition of RHA to concrete exhibited an increase in the flexural strength and the higher strength was for the finer RHA mixture due to the increased pozzolanic reaction and the packing ability of the RHA fine particles

Kartini et al (2010) investigation carried out compressive strength on 100mm cube specimens at age of 1, 3, 7, 28, 90, 180and 365 days was tested. Without Sp (Superplasticer), RHA concrete attained lower compressive strength than that of the control due to the higher amount of water for similar workability. By adding Sp to the RHA mixes, higher replacement levels are possible. Concrete containing up to 30% RHA can attain strength of 30 N/mm2 at 28 days

Chindaprasirt et al (2008) had reported strength of the mortar containing FA, RHA and the ternary blended cement were relatively high. The strengths of mortar containing 10% and 20% of pozzolans and blend of pozzolans are higher than that of the control at all ages. Only the strength at 7 days of mortar containing 10% FA + 10% RHA (10FA10RHA) is slightly lower than that of the OPC mortar at the same age. The increase in the amount of replacement to 40%reduces the early strength of both FA and RHA mortars. However, the strength at the ages of 28 and 90 days of both FA and RHA mortars are slightly higher than that of the control. This indicates that both FA and RHA are pozzolanic materials and the early pozzolanic reaction rate is thus slow. The pozzolanic reaction of both cases, however, can be seen at the age of 28 days onwards resulting in the higher strength of both FA and RHA mortar in comparison to that of the control. The results indicate that for the high replacement level of 40%, the use of blend of RHA and FA improves the early strength development of mortar in comparison to normal single pozzolan mortar.

Satish et al (2013) was indicated the comparison of results of compressive strength using cube specimen of M25 grade of concrete for different percentage of cement, RHA and FA. Target strength of M25 concrete was 32.1 Mpa, but convention concrete gives 45.78Mpa compressive strength at 28 days of curing. Comparative work shows maximum compressive strength obtained at combination of 22.5% FA and 7.5% RHA which was less than strength of control concrete but greater than target strength. It was observed that 30.15% strength was increase as compared to target strength and 8.73% strength decreases as compared to control concrete at 28 days of curing. It was observed that maximum flexural strength was obtained at combination of 22.5% FA and 7.5% RHA and strength was increase by 4.57% as compared to control concrete at 28 days of curing.

MATERIAL AND PROPERTIES

Cement

Ordinary Portland cement (OPC) 43 grade of specific gravity of 3.15 conforming to Indian standard code 8112 was used. Particle size distribution of OPC was determined. Physical properties such as specific gravity and surface area of Ordinary Portland Cement (OPC) were determined as per IS 8112 and IS 4031 (part 2)-1995 using Blain‘s air permeability apparatus (surface area). Chemical composition (IS 4032-1985) and physical properties of OPC are given in Table

Table Chemical composition of Ordinary Portland Cement (OPC)

Chemical composition	**Percentage**	**IS 8112-1989 requirement**	**ASTM C150 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.	**Name of the properties**	**Obtained Value**	**Confirmation Code**
1.	Specific gravity	3.12	IS 4031:1988 * **Permissible range 3.1 – 3.15**
2.	Fineness	348 m^2/kg	IS 8112-1989 * **Shall not be less than 225 m^2/kg**
3.	Consistency	31 (%)	IS 8112-1989 * **Permissible range 30 – 35 (%)**

4.	Initial setting time	45(min)	IS 8112-1989 *** Not less than 30 min.**
5.	Final setting time	225 (min)	IS 8112-1989 *** Not more than 600 min.**
6.	Soundness	2 mm	IS 8112-1989 *** shall not be more than 10mm**

Fine aggregate

Graded river sand passing through 4.75 mm sieve with fineness modulus of 2.63 and specific gravity of 2.60 is used as fine aggregate and physical properties of fine aggregates given in Table 3.5. The grading of aggregate (fine) was conforming to Zone III as per IS 383-1970 and is given in Table

Table : Grading of fine aggregate

IS Sieve (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

Table Physical properties of coarse and fine aggregates

S. No.	**Aggregte**	**Name of the properties**	**Obtained Value**	**Confirmation Code**
1.	Fine	Specific gravity	2.60	IS 383-1970& ASTM C12 *** minimum 2.6**
		Finesse modules	2.63	IS 383-1970 ASTM C136 *** ranges 2.3 to 3.1**
		Bulk density	1693 Kg/m^3	IS 2386 (Part III) 1963
2.	Coarse	Specific gravity	2.70	IS 383-1970 *** minimum 2.6**
		Finesse modules	6.26	IS: 2386-1963 part 3
		Bulk density	1527 Kg/m^3	IS 383-1970

Coarse Aggregate

Coarse aggregate is locally available crushed granite aggregate, passing through 12.5 mm sieve and retained on 4.75 mm sieve with fineness modulus of 6.26 conforming to IS 383-1970. Physical properties and grading of coarse aggregates are given in Table

Table Grading of coarse aggregate

IS Sieve (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

Fly ash – F

Fly ash for this study was taken from Vindhyachal Super Thermal Power Plant (STPS) located in Singrauli District M.P. shown in Figure 3.1. From the source class F type fly ash was collected of size 45 μm. It is advisable that to all parameter of fly ash conforming to replacement of IS 3812 -1981& ASTM C618 limits for class F fly ash use in concrete. The physical properties and chemical composition of Fly ash is given in Table

Fig. Class – F fly ash

Table Physical properties of fly ash – F

S. No.	**Properties**	**Obtained Value**	**Permissible value as per IS 3812-1981**
1.	Specific gravity	2.07	-
2.	Fineness	$527m^2/kg$	Shall not be less than $320m^2/kg$
3.	Bulk Density	$1190kg/m^3$	-

Table Chemical composition of fly ash – F

Chemical composition	**Percentage**	**IS 3812 – 1981 Requirement**	**ASTM C 618 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	5.0 max
LOI	2.47	5.0max	6.0 max
SiO_2+ Al_2O_3+Fe_2O_3	86.78	70.0 min	70.0 min

Rice Husk Ash

Rice husk residue was collected from a rice mill at Dabra, Gwalior M.P, India. Initially rice husk was converted into ash by open burning method at a temperature ranging from 300^0C to 450^0C. The amount of un-burnt carbon was found in (end product) ash at a temperature below 650^0C. The fired rice husk ash was black in color obviously due to excess amount of carbon content. The fired husk residue ash was further burnt to a temperature of 650^0 C over a period of 2 h and made in to a mean grain size of 3.8 μm before it is used as a cement replacement material (Ganesan et al 2004 and 2008).The conversion processes of RHA are shown in Figure 3.2 to 3.5. The specific gravity and bulk density of rice husk ash as per IS1727-1995 was determined. Specific surface area of RHA was measured using BET‘s method by nitrogen adsorption and given in Table Chemical analyses for oxide composition of RHA are given in Table

Figure Collected rice husk residue (Stage-I)

Figure Rice husk was converted into ash by open burning method at a temperature ranging from 300^{0}C to 450^{0}C

(Stage-II)

Figure Fired husk residue ash was further burnt at a temperature of 650^{0}C over a period of 2 h (Stage-III)

Figure Obtained RHA grain size of 3.8um (Stage-IV)

Table Physical properties of Rise Husk Ash (RHA)

S. No.	Properties	Obtained Value
1.	Specific gravity	2.01
2.	Fineness BET‘s method by nitrogen adsorption	3460 m^2/kg
3.	Bulk Density	696 kg/m^3

Table 3.9 Chemical composition of Rice Husk Ash (RHA)

Chemical composition	Percentage	IS 3812 – 1981 requirement	ASTMC 618-94arequirement
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	4.0 max
LOI	2.26	5.0max	10.0 max
SiO_2+ Al_2O_3+Fe_2O_3	88.11	70.0 min	70.0 min

Egg Shell Powder

Egg shells were collected from Namakkal in Tamil Nadu. It is India's egg export hub and accounts for over 90 % of India's total egg exports. The average weight of one egg shell is 7.2 to 7.8 gm. Egg shell was washed thoroughly (to remove organic properties) and dried in sun light 5 to 7 days and made in to a powdery substance to obtained an average particle size of 45 μm is shown in Figure 3.6 and 3.7 .The physical properties and chemical composition of Egg shell powder (ESP) is given in Table

Table 3.10 Physical properties of Egg Shell Powder (ESP)

S. No.	Properties	Obtained Value
1.	Specific gravity	1.89
2.	Fineness	290 m^2/kg
3.	Bulk Density	1081kg/m^3

Table Chemical composition of Egg Shell Powder (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	

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

REFERENCES:

1. Ade Sri Wahyuni, FepySupriani, Elhusna & Agustin Gunawan. 2014, ‗The performance of concrete with rice husk ash, sea shell ash and bamboo fibre addition', Procedia Engineering, 2nd International Conference on Sustainable Civil Engineering Structures and Construction Materials (SCESCM 2014), vol. 95, pp.473-478.
2. Aggarwal, P., Aggarwal, Y & Guptha, S.M 2007, ‗Effect of Bottom ash as replacement of Fine aggregates in concrete', Asian Journal of Civil Engineering (Building and Housing), vol. 8, no. 1, pp. 49-62.
3. Ahmaruzzaman, M 2010, ‗A review on the utilization of fly ash', Progress in Energy and Combustion Science, vol. 36, pp. 327-363.
4. Ahmet Raif Boga & Ilker Bekir Topçu 2012, ‗Influence of fly ash on corrosion resistance and chloride ion permeability of concrete', Construction and Building Materials, vol. 31, pp. 258-264.

5. Alireza Naji Givi, Suraya Abdul Rashid, Farah Nora A. Aziz & Mohamad Amran Mohd Salleh 2010a, ‗Contribution of Rice Husk Ash to the Properties of Mortar and Concrete: A Review', Journal of American Science, vol. 06, no. 03, pp. 157-165.
6. Alireza Naji Givi, Suraya Abdul Rashid, Farah Nora A. Aziz & Mohamad Amran Mohd Salleh 2010b, ‗Assessment of the effects of rice husk ash particle size on strength, water permeability and workability of binary blended concrete', Construction and Building Materials, vol. 24, pp. 2145-2150.
7. Andres E. Idiart, Carlos M. Lopez & Ignacio Carol 2011, ‗Chemo mechanical analysis of concrete cracking and degradation due to external sulphate attack', Cement and Concrete Composites, vol. 33, no. 3, pp. 411-423.
8. Andri Kusbiantoro, Muhd Fadhil Nuruddin, Nasir Shafiq & Sobia Anwar Qazi 2012, ‗The effect of microwave incinerated rice husk ash on the compressive and bond strength of fly ash based geopolymer concrete', Construction and Building Materials, vol. 36, pp. 695-703.
9. Aydin, S, Yazici, H, Yigiter, H & Baradan, B 2007, ‗Sulfuric acid resistance of high-volume fly ash concrete', Build Environ vol. 42, pp. 717-721
10. Binu Sukumar, Nagamani, K & Srinivasa Raghavan, R 2008, ‗Evaluation of strength at early ages of self-compacting concrete with high volume fly ash', Construction and Building Materials, vol. 22, no.7, pp. 1394-140.
11. Bhanumathidas, N & Mehta P.K, 2004, ‗Concrete mixtures made with ternary blended cements containing fly ash and RHA', International conference proc. seventh CANMET, vol. 1, pp. 379–391.
12. Bouzoubaa, N, Zhang, M.H & Malhotra, V.M 2001, ‗Mechanical properties and durability of concrete made with high-volume fly ash blended cements using a coarse fly ash' Cement and Concrete Research, vol.31, no. 10, pp. 1393-1402.
13. Chindaprasirt, P & Rukzon, S 2008, ‗Strength, porosity and corrosion resistance of ternary blend Portland cement, rice husk ash and fly ash mortar', Construction and Building Materials, vol. 22, no. 8, pp. 1601- 1606.
14. Chindaprasirt, P, Chareerat, T, Hatanaka, S & Cao, T 2011, ‗High- Strength Geopolymer Using Fine High-Calcium Fly Ash', ASCE, vol. 23, no. 3, pp. 264-270.
15. Chindaprasirt, P, Homwuttiwong, S & Jaturapitakkul, C 2007, ‗Strength and water permeability of concrete containing palm oil fuel ash and rice husk–bark ash', Construction and Building Materials, vol. 21, no. 7, pp. 1492-1499.
16. Chindaprasirt, P, Homwuttiwong, S & Sirivivatnanon, V 2004, ‗Influence of fly ash fineness on strength, drying shrinkage and sulphate resistance of blended cement mortar', Cement and Concrete Research, vol.34, no. 7, pp. 1087-1092.
17. Chindaprasirt, P, Kanchanda, P, Sathonsaowaphak, A & Cao, H.T 2007, ‗Sulfate resistance of blended cements containing fly ash and rice husk ash', Construction and Building Materials, vol. 21, no. 6, pp.1356-1361.
18. Chindaprasirt, P, Rukzon, S & Sirivivatnanon, V 2008, ‗Resistance to chloride penetration of blended Portland cement mortar containing palm oil fuel ash, rice husk ash and fly ash', Construction and Building Materials, vol. 22, no. 5, pp. 932-938.
19. Chuanlin, Hu & Zongjin, Li 2015, ‗Property investigation of individual phases in cementitious composites containing silica fume and fly ash', Cement & Concrete Composites, vol. 57, pp. 17-26.
20. Chuanlin, Hu 2014, ‗Microstructure and mechanical properties of fly ash blended cement pastes', Construction and Building Materials, vol. 73, pp. 618-625.
21. Collepardi, M 2003, ‗A state-of-the-art review on delayed ettringite attack on concrete', Cement& Concrete Composites, vol. 25, no. 4, pp. 401-407.
22. Deepa G. Nair, Jagadish, K.S & Alex Fraaij, 2006, ‗Reactive pozzolanas from rice husk ash: An alternative to cement for rural housing', Cement and Concrete Research, vol.36, no. 6, pp. 1062-1071.
23. Della, V. P., Kühn I & Hotza D, 2002, ―RHA as an alternate source for active silica production‖, Journal of material science, Vol. 57, pp. 818-821
24. Dhir, RK, El-Mohr, MAK & Dyer, TD 1997, ‗Developing chloride resisting concrete using PFA', Cement and Concrete Research vol. 27, no. 11, pp. 1633-1639.
25. Dinakar, P, Babu, KG & Manu Santhanam 2008, ‗Durability properties of high volume fly ash self- compacting concretes', Cement& Concrete Composites, vol. 30, no. 10, pp. 880-886.
26. Divya Chopra, Rafat Siddique & Kunal 2015, ‗Strength, permeability and microstructure ofself-compacting concrete containing rice husk ash', Bio systems Engineering, vol. 130, pp. 72-80.
27. Duran-Herrera, A, Juarez, CA, Valdez, P & Bentz, DP 2011, ‗Evaluation of sustainable high-volume fly ash concretes', Cement & Concrete Composites, vol. 33, no. 1, pp. 39-45.

28. Elli Makrides Saravanos,(1995),―Engineering Properties of High performance Concrete containing Large Volume of Class C Fly ash Ph.D thesis. University of Saskatchewan, Canada.

29. Feldman, RF, Carette, GG & Malhotra, VM 1990, ‗Studies mechanism of development of physical and mechanical properties of high volume fly ash cement paste', Cement and Composites, vol. 12, no. 4, pp. 245-251.

30. Gao Li-xiong, Yao Yan & Wang Ling, 2004, ―Research on sintered Flyash aggregate of high strength and low absorption of water‖, Proceedings of the International Workshop on Sustainable Development and Concrete Technology, Vol. 6, pp. 715-721

31. Ganesan, K, Rajagopal, K & Thangavel, K 2004, ‗Rice husk ash- a versatile supplementary cementitious material', Indian Concrete Institute Journal, vol. 02, pp. 29-34.

32. Ganesan, K, Rajagopal, K & Thangavel, K 2007, ‗Chloride resisting concrete containing rice husk ash and bagasse ash', Indian Journal of Engineering and Materials Science, vol. 14, pp. 125-130

33. Ganesan, K, Rajagopal, K & Thangavel, K 2008, ‗Rice husk ash blended cement: Assessment of optimal level of replacement for strength and permeability properties of concrete'. Construction and Building Materials, vol. 22, no. 8, pp. 1675-1683.

34. Gastaldini, ALG, Da Silva, MP, Zamberlan, FB & Mostardeiro Neto, CJ 2014, ‗Total shrinkage, chloride penetration, and compressive strength of concretes that contain clear-colored rice husk ash', Construction and Building Materials, vol. 54, pp. 369-377.

35. Gastaldini, ALG, Isaia, GC, Hoppe, TF, Missau, F & Saciloto, AP 2009, ‗Influence of the use of rice husk ash on the electrical resistivity of concrete: A technical and economic feasibility study', Construction and Building Materials, vol. 23, no. 11, pp. 3411-3419.

36. Gastaldini, ALG, Isaia, GS, Gomes, NS & Sperb, JEK 2007, ‗Chloride penetration and carbonation in concrete with rice husk ash and chemical activators', Cement & Concrete Composites, vol. 29, no. 3, pp. 176-180.

37. Gemma Rodríguez De Sensale 2010, ‗Effect of rice-husk ash on durability of cementitious materials', Cement & Concrete Composites, vol. 32, no. 9, pp. 718-725.

38. Guomundur Hannesson, Katherine Kuder, Rob Shogren & Dawn Lehman 2012, ‗The influence of high volume of fly ash and slag on the compressive strength of self-consolidating concrete', Construction and Building Materials, vol. 30, pp. 161-168.

39. Guilherme Chagas Cordeiro, Romildo Dias Toledo Filho, Luis Marcelo Tavares, Eduardo de Moraes Rego Fairbairn & Simone Hempel 2011, ‗Influence of particle size and specific surface area on the pozzolanic activity of residual rice husk ash', Cement & Concrete Composites, vol. 33, no. 5, pp. 529-534.

40. Guilherme Chagas Cordeiro, Romildo Dias Toledo Filho, Luis Marcelo Tavares, Eduardo de Moraes Rego Fairbairn & Simone Hempel 2011, ‗Influence of particle size and specific surface area on the pozzolanic activity of residual rice husk ash', Cement & Concrete Composites, vol. 33, no. 5, pp. 529-534.

41. Habeeb, GA & Fayyadh, MM 2009, ‗Rice Husk Ash Concrete: the Effect of RHA Average Particle Size on Mechanical Properties and Drying Shrinkage', Australian Journal of Basic and Applied Sciences, vol. 3, no. 3, pp. 1616-1622.

42. Harish Kizhakkumodom Venkatanarayanan & Prasada Rao Rangaraju, 2015, ‗Effect of grinding of low-carbon rice husk ash on the microstructure and performance properties of blended cement concrete', Cement & Concrete Composites, vol. 55, pp. 348-363.

43. Hasan Yildirim, Mansur Sumer, Veysel Akyuncu & Emrah Gurbuz. 2011, ‗Comparison on efficiency factors of F and C types of fly ashes', Construction and Building Materials, vol. 25, no. 6, pp. 2939-2947.

44. Hwang Chao-Lung, Bui Le Anh-Tuan & Chen Chun-Tsun 2011, ‗Effect of rice husk ash on the strength and durability characteristics of concrete', Construction and Building Materials, vol. 25, no. 9, pp. 3768-3772.

45. Jamil, M, Kaish, ABMA, Raman, SN & Zain, MFM 2013, ‗Pozzolanic contribution of rice husk ash in cementitious system', Construction and Building Materials, vol. 47, pp. 588-593.

46. Kaewkhao, J & Limsuwan, P 2014, ‗Utilization of rice husk fly ash in the color glass production', Procedia Engineering, I-SEE2011, vol. 32, pp. 670-675.

47. Kartini, K, Artini, K, Mahmud, HB & Hamidah, MS 2010, ‗Absorption and Permeability Performance of Selangor Rice husk ash blended Grade 30 Concrete', Journal of Engineering Science and Technology, Taylor's University College, vol. 5, no. 1, pp. 1-16.

48. Kathirvel, P, Saraswathy, V, Karthik, SP & Sekar, ASS 2011,‗Strength and durability properties of quaternary cement concrete made with fly ash, RHA and LP', Arabian Journal for Science and Engineering, vol. 38, no. 3, pp. 589-598.

49. Krishna, RN 2012, ‗Rice husk ash – An ideal admixture for concrete in aggressive environments', 37th Conference on Our World in Concrete & Structures, Singapore, Article Online Id:100037026, pp. 29-31.

50. Linhua Jiang, Zhenqing Liu & Yiqun Ye 2004, ‗Durability of concrete incorporating large volumes of low-quality fly ash'. Cement and Concrete Research, vol.34, no. 8, pp. 1467-1469.

51. Lorca, P, Calabuig, R, Benlloch, J, Soriano, L & Paya, J 2014, ‗Micro concrete with partial replacement of Portland cement by fly ash and hydrated lime addition', Materials and Design, vol. 64, pp. 535-541.

52. Mansur Sumer 2012, ‗Compressive strength and sulfate resistance properties of concretes containing Class F and Class C fly ashes', Construction and Building Materials, vol. 34, pp. 531-536.

53. Mehta, PK 1983, ‗Pozzolanic and cementitious products as mineral admixtures for concrete a critical view', ACI material journal, vol. 79, no. 1, pp. 1-46.

54. Miranda, JM, Fernanndez-Jimennezb, A, Gonzalezc, JA & Palomob, A 2005, ‗Corrosion resistance in activated fly ash mortars', Cement and Concrete Research, vol. 35, no 6, pp. 1210-1217.

55. Mohammed Razzaq Mohammed 2012, ‗Effect of Egg shells powder some Mechanical and Physical properties of Natural Rubber' The Iraqi Journal For Mechanical And Material Engineering, vol.12, no. 4, pp. 426-458.

56. Mtallib MOA and Rabiu, A 2012, ‗Effects of Eggshells Ash (ESA) on the setting time of cement', Nigerian Journal of Technology, vol. 28, pp. 29-38.

57. Mehta, PK 1990, ‗Durability of high strength concrete', proceeding of the paulklieger symposium', ACI SP, vol. 122, pp. 19-27.

58. Mucteba Uysal & Veysel Akyuncu 2012, ‗Durability performance of concrete incorporating Class F and Class C fly ashes', Construction and Building Materials, vol. 34, pp. 170-178.

59. Nader Ghafoori, Meysam Najimi, Hamidou Diawara, & Mohammad S. Islam 2015, ‗Effects of class F fly ash on sulfate resistance of Type V Portland cement concretes under continuous and interrupted sulphate exposures' Construction and Building Materials, vol. 78, pp. 85-91.

60. Nehdi, M, Duquette, J & El Damatty, A 2003, ‗Performance of rice husk ash produced using a new technology as a mineral admixture in concrete', Cement and Concrete Research, vol.33, no. 8, pp. 1203- 1210.

61. Nguyen Tien Dung, Ta-Peng Chang & Chun-Tao Chen 2014, ‗Engineering and sulfate resistance properties of slag-CFBC fly ash paste and mortar', Construction and Building Materials, vol. 63, pp. 40-48.

62. Nguyen Van Tuan, Guang Ye, Klaas Van Breugel, Alex, LA. Fraaij Bui & Danh Dai 2010, ‗The study of using rice husk ash to produce ultra-high performance concrete', Construction and Building Materials, vol. 25, no. 4, pp. 2030-2035.

63. Obada Kayali & Sharfuddin Ahmed, M 2013, ‗Assessment of high volume replacement fly ash concrete – Concept of performance index', Construction and Building Materials, vol. 39, pp. 71-76.

64. Okonkwo, U, Odiong, I & Akpabio, E 2012, ‗The effects of eggshell ash on strength properties of cement-stabilized lateritic', International Journal of Sustainable Construction Engineering & Technology vol. 3, no. 1, pp. 242-250.

65. Ondova, M, Stevulova, N & Estokova, A 2012, ‗The study of the properties of fly ash based concrete composites with various chemical admixtures', Proceedings the20thInternational Congress of Chemical and Process Engineering, Prague, Czech Republic, vol. 42, pp.1863-1872.

66. Oner, A, Akyuz, S & Yildiz, R 2005, ‗An experimental study on strength development of concrete containing fly ash and optimum usage of fly ash in concrete', Cement and Concrete Research, vol.35, no. 6, pp. 1165-1171.

67. OzkanSengul & Mehmet Ali Tasdemir 2009, ‗Compressive Strength and Rapid Chloride Permeability of Concretes with Ground Fly Ash and Slag', Journal of Materials in Civil Engineering, vol. 21, no. 9, pp. 494-501.

68. Pattanapong Topark-Ngarm, Prinya Chindaprasirt & Vanchai Sata, 2009, ‗Setting Time, Strength, and Bond of High-Calcium Fly Ash Geopolymer Concrete', Journal of Material in Civil Engineering, vol. 01, no. 4, pp. 01-07.

69. Pavel Siler, Petr Bayer, Tomas Sehnal, Iva Kolarova, Tomas Opravil & Frantisek Soukal 2015, ‗Effects of high-temperature fly ash and fluidized bed combustion ash on the hydration of Portland cement', Construction and Building Materials, vol. 78, pp. 181-188.

70. Pavía, S, Walker, Veale, P & Wood, A 1014, ‗Impact of the Properties and Reactivity of Rice Husk Ash on Lime Mortar Properties', American Society of Civil Engineers. vol. 26, no. 9, pp. 1-8.

71. Poon, CS, Lam, L & Wong, YL 2000, ‗A study on high strength concrete prepared with large volumes of low calcium fly ash', Cement and Concrete Research, vol.30, no 4, pp. 447-455.

72. Prinya Chindaprasirt, Chai Jaturapitakkul & Theerawat Sinsiri 2007, ‗Effect of fly ash fineness on microstructure of blended cement paste', Construction and Building Materials, vol. 21, no 7, pp. 534-1541.

73. Qingge Feng, Yamamichi, H, Shoya, M & Sugita, S 2004, ‗Study on the pozzolanic properties of rice husk ash by hydrochloric acid pretreatment', Cement and Concrete Research, vol.34, no 3, pp. 521-526.

74. Rafat Siddique 2003, ‗Properties of concrete incorporating high volumes of class F fly ash and san fiber', Cement and Concrete Research, vol.13, no 1, pp. 547-556.

75. Rafat Siddique 2004, ‗Performance characteristics of high-volume Class F fly ash concrete', Cement and Concrete Research, vol.34, no 4, pp. 487-493.

76. Rahmana, ME, Muntohar, AS, Pakrashi, P, Nagaratnam, BH & Sujan, D 2014, ‗Self compacting concrete from uncontrolled burning of rice husk and blended fine aggregate‗, Materials and Design, vol. 55, pp. 410-415.

77. Rahmat Madandoust, Malek Mohammad Ranjbar, Hamed Ahmadi Moghadam & Seyed Yasin Mousavi 2011, Bio-systems Engineering, vol. 110, pp. 144-152.

78. Ramana, SN, Ngo, T, Mendis, P & Mahmud, HB 2011, ‗High-strength rice husk ash concrete incorporating quarry dust as a partial substitute for sand', Construction and Building Materials, vol. 25, no 7, pp. 3123-3130.

79. Ramasamy, V 2012, ‗Compressive Strength and Durability Properties of Rice Husk Ash Concrete', KSCE Journal of Civil Engineering, vol. 16, no. 1, pp. 93-102.

80. Raoul Jauberthie, Frank Rendell, SeniTamba & Ibrahima Khalil Cisse 2013, ‗Properties of cement—rice husk mixture', Construction and Building Materials, vol. 17, no 4, pp. 239-243.

81. Ravandekishore, Bhikshma, V & Jeevanprakash, 2011, ‗Study on Strength Characteristics of High Strength Rice Husk Ash Concrete', Procedia Engineering, The Twelfth East Asia-Pacific Conference on Structural Engineering and Construction, vol. 14, pp.2666-2672.

82. Rego, JHS, Nepomuceno, AA, Figueiredo, EP & Hasparyk, NP 2015, ‗Microstructure of cement pastes with residual rice husk ash of low amorphous silica content', Construction and Building Materials, vol. 80, pp. 56-68.

83. Ru-Shan Bie, Xing-Fei Song, Qian-Qian Liu, Xiao-Yu Ji & Pei Chen 2015, ‗Studies on effects of burning conditions and rice husk ash (RHA) blending amount on the mechanical behavior of cement', Cement & Concrete Composites, vol. 55, pp. 162-168.

84. Sakr, K 2006, ‗Effects of Silica Fume and Rice Husk Ash on the Properties of Heavy Weight Concrete', Journal of Materials in Civil Engineering, vol. 18, no 3, pp. 367-376.

85. Saraswathy, V & Ha-Won Song 2007, ‗Corrosion performance of rice husk ash blended concrete'. Construction and Building Materials, vol. 21, no 8, pp. 1779-1784.

86. Saraswathy, V, Muralidharan, S, Thangavel, K & Srinivasan, S 2003, ‗Influence of activated fly ash on corrosion-resistance and strength of concrete', Cement & Concrete Composites, vol. 25, no 6, pp. 673-680.

87. Saricimen, H, Maslehuddin, M, Al-Tayyib, AJ & Al-Mana, AI 1995, ‗Permeability and durability of plain and blended cement concrete in field and laboratory', ACI Material Journal, vol. 2, no 2, pp. 111-116.

88. Satish, H Sathawane, Vikrant S Vairagade & Kavita S Kene 2013,'Combine Effect of Rice Husk Ash and Fly Ash on Concrete by 30%Cement Replacement', Procedia Engineering, Chemical, Civil and Mechanical Engineering Track of 3 rd Nirma University International Conference, vol. 51, pp. 35-44.

89. Shaikh, FUA, Supit, SWM & Sarker, PK 2014, ‗A study on the effect of nano silica on compressive strength of high volume fly ash mortars and concretes', Materials and Design, vol. 60, pp. 433-442.

90. Shane Donatello, Angel Palomo & Ana Fernández-Jiménez 2013, ‗Durability of very high volume fly ash cement pastes and mortars in aggressive solutions', Cement & Concrete Composites, vol. 38, pp. 12-20.

91. Sharma, N.K., Williams, W.S. & Zangvil, A. 1984 ―Formation and Structure of Silicon Carbide Whiskers from Rice Hulls‖, J.Amer. Ceram. Soc., Vol. 67, pp.717-725

92. Speare, PRS, Eleftheriou, K & Siludom, S 1999, ‗Durability of concrete containing rice husk ash as an additive', Proceeding of International Seminar on Creating Waste in Concrete, Dundee, United Kingdom, vol. 05, pp. 283-290.

93. Sutas, J, Mana, A & Pitak, L 2012, ‗Effect of Rice Husk and Rice Husk Ash to Properties of Bricks', Procedia Engineering, I-SEEC2011, vol. 32, pp.1061-1067.

94. Tsong Yen, Tsao-Hua Hsu, Yu-Wen Liu & Shin-Ho Chen 2007, ‗Influence of class F fly ash on the abrasion–erosion resistance of highstrength concrete', Construction and Building Materials, vol. 21, pp.458-464.

95. Vanchai Sata, Apha Sathonsaowaphak & Prinya Chindaprasirt 2012,' Resistance of lignite bottom ash geopolymer mortar to sulfate and sulfuric acid attack', Cement & Concrete Composites, vol. 34, pp. 700-708.

96. Veera Horsakulthai & Kittichat Paopongpaiboon 2013, ‗Strength, chloride permeability and corrosion of coarse fly ash concrete with Bagasse-Rice husk-Wood ash additive' American Journal of Applied Sciences, vol. 10, no. 3, pp. 239-246.
97. Veera Horsakulthai, Santi Phiuvanna & Watcharase Kaenbud 2011, ‗Investigation on the corrosion resistance of bagasse-rice husk-wood ash blended cement concrete by impressed voltage', Construction and Building Materials, vol. 25, pp.54-60.
98. Wada, I, Kamano, T, Kawakami, M & Maeda, N 2000, ‗Effect of highly reactive rice husk ash on durability of concrete and mortar', Proc fifth international conference ACI durability of concrete, Barcelona, Spain, vol. 1, pp. 205-222.
99. Watcharapong Wongkeo, Pailyn Thongsanitgarn, Athipong Ngamjarurojana & Arnon Chaipanich 2014, ‗Compressive strength and chloride resistance of self-compacting concrete containing high level fly ash and silica fume', Materials and Design, vol. 64, pp. 261-269.
100. Yilmaz Kocak & Suna Nas 2014, ‗The effect of using fly ash on the strength and hydration characteristics of blended cements', Construction and Building Materials, vol. 73, pp.25-32.