ASSESSMENT OF CONCRETE STRENGTH USING FLYASH AND RICE HUSK ASH

Satish D. Kene[1], Pravin V. Domke[2], Sandesh D. Deshmukh[3], R.S.Deotale[4]

[1,2,3] (Research Scholar, Department of Civil Engineering, YCCE, Nagpur-10, Maharashtra, India.

Email: satishkene2285@gmail.com, pravindomke@rediffmail.com, sandesh_deshmukh31@rediffmail.com)

[4] (Assistant Professor, Department of Civil Engineering, YCCE, Nagpur-10, Maharashtra, India.

Email: : rsdeotale1@rediffmail.com)

ABSTRAC

In the ancient period, construction work was mostly carried out with help of mudstone from industry. Fly ash is a by-product of burned coal from power station and rice husk ash is the by –product of burned rice husk at higher temperature from paper plant. Considerable efforts are being taken worldwide to utilise natural waste and bye –product as supplementary cementing materials to improve the properties of cement concrete. Rice husk ash (RHA) and Fly ash (FA) is such materials. RHA is bye-product of paddy industry. Rice husk ash is a highly reactive pozzolanic material produced by controlled burning of rice husk. FA is finely divided produced by coal-fired power station. Fly ash possesses pozzolonic properties similar to naturally occurring pozzolonic material. The detailed experimental investigation done to study the effect of partial replacement of cement with RHA and FA on concrete. In this paperI started proportion form 30% FA and 0% RHA mix together in concrete by replacement of cement ,last proportion taken 0% FA and 30% RHA, with gradual increase of RHA by 1% and simultaneously gradual decrease of FA by 1%. It is observed that though the strength of RHA concrete goes on decreasing after the 15% addition of RHA, the composition of 10% RHA + 20% FA gives maximum strength results as well as shows the potential to be used as useful material for different building materials

Keywords – Admixture, Concrete, Compressive Strength, Fly Ash, Multiple Regression Analysis, Rice husk Ash.

I. INTRODUCTION

Concrete as is well known is a heterogeneous mix of cement, water and aggregates. The admixtures may be added in concrete in order to enhance some of the properties desired specially. In its simplest form, concrete is a mixture of paste and aggregates. Various materials are added such as fly ash, rice husk, admixture to obtain concrete of desired property. The character of the concrete is determined by quality of the paste. The key to achieving a strong, durable concrete rests in the careful proportioning, mixing and compacting of the ingredients. The detailed experimental investigation done to study the effect of partial replacement of cement with RHA and FA on cement. In this project I started proportion form 30% FA and 0% RHA mix together in concrete by replacement of cement ,last proportion taken 0%FA and 30% RHA. Numerous tests are performed on wet concrete such as workability tests such as compaction factor test and slump test. The tests on hardened concrete are destructive test while the destructive test includes compressive test on concrete cube for size (150 x 150 x 150) mm, Flexural strength on concrete beam (500 x 100 x100) and split tensile

strength on concrete cylinder (150 mm ø x 300mm) as per IS: 516 – 1959, IS: 5816 – 1999 and IS: 516 – 1959 respectively.In actual practice, test on workability of wet concrete are carried out to ensure uniform quality concrete only. Strength is not a measurable at that stage with the available technology. Therefore the concrete samples are to be cured for 28 days in normal method to arrive at the compressive strength and for necessary follow up action. It is not only difficult to dismantle the suspected portion of concrete at such a stage but also expensive in terms of time and money. Predicting the strength at the manufacturing stage, however, is yet to receive due attention of engineers. Hence, any new approach that is capable of predicting reliably the compressive strength of hardened concrete based on the properties of the ingredients and the wet concrete will be helpful to practicing engineers. Besides, such tests could be performed with the same ease as the workability tests. RHA has two roles in concrete manufacture, as a substitute for cement, reducing the cost and weight of concrete in the production of low cost building blocks. The workability of RHA concrete has been found to decrease but FA increases the workability of concrete so RHA and FA mix together in concrete to improve the workability of concrete. The work presented in thispaper reports an investigation on the behavior of concrete produced from blending cement with FA and RHA.

Regression analysis method for predicting the 7,14,28,90 day's compressive strength of concrete is presented in this project. The proposed method is aimed at establishing a predictive relationship between properties and proportions of ingredients of concrete, compaction factor, weight of concrete cubes and strength of concrete

The objectives and scope of present study are.

- To find the optimum mix design with regards to the amount of water, RHA, FA and cement ratio.
- To investigate the physical properties of the RHA and FA– density (lightweight), strength (bending and compression), water absorption and moisture content.
- To study the relative strength development with age of (RHA + FA) concrete with control concrete.
- Use of industrial waste in a useful manner.
- To conduct compression test on (RHA+FA) and control concrete on standard IS specimen size (150 x 150 x 150) mm.
- To conduct Flexural test on (RHA+FA) and control concrete on standard IS specimen size (100 x 100 x 500) mm.
- To conduct split tensile test on (RHA+FA) and control concrete on standard IS specimen size (150 mm ø x 300mm) mm.
- To provide economical construction material.
- Provide safeguard to the environment by utilizing waste properly.

II. Materials and Methods

The work presented in this paper reports an investigation on the behaviour of concrete produced from blending cement with RHA and FA. The physical and chemical properties of RHA, FA and OPC were first investigated. Mixture proportioning was performed to produce high workability concrete (200- 240 mm slump) with target strength of 32.1 Mpa (M25) for the control mixture. The effect of RHA on concrete properties was studied by means of the fresh properties of concrete and the mechanical properties. I.e. Compressive strength, tensile splitting strength, flexural test was studied as the time dependent property.

A. Cement

The cement used was Ordinary Portland cement (43 Grade) with a specific gravity of 3.15. Initial and final setting time of the cement was 50 min and 365 min, respectively. Its chemical composition is given in Table 1.

Table 1: Following are the Chemical properties of cement (OPC), Fly ash and Rice husk ash

Materials	SiO2	Al2O3	Fe2O3	CaO	MgO	LOI	SO3	K2O	Na2O3
Cement	*19.71*	*5.20*	*3.73*	*62.91*	*2.54*	*0.96*	*2.72*	*0.90*	*0.25*
Fly ash	*40*	*25*	*6*	*20*	*3.71*	*3.0*	*1.74*	*0.80*	*0.96*
Rice husk ash	*78.21*	(SiO2+ Al2O3+ Fe2O3) =82.64		*0.99*	*4.89*	--------	--------	---------	---------

B. Rice Husk Ash

Rice husk ash used was obtained from Ellora Paper Plant located in Tumsar Bhandara .The Specific gravity of rice husk ash is 2.10 and bulk density is 0.781 g/cc RHA, produced after burning of Rice husk (RH) has high reactivity and pozzolanic property. Indian Standard code of practice for plain and reinforced concrete, IS 456- 2000, recommends use of RHA in concrete but does not specify quantities. Chemical compositions of RHA are affected due to burning process and temperature. Silica content in the ash increases with higher the burning temperature. As per study by Houston, D. F. (1972) RHA produced by burning rice husk between 600 and 700°C temperatures for 2 hours, contains 90-95% SiO_2, 1-3% K_2O and < 5% unburnt carbon. Under controlled burning condition in industrial furnace, Studies have shown that RHA resulting from the burning of rice husks at control temperatures have physical and chemical properties that meet ASTM (American Society for Testing and Materials).Standard C 618-94a. Studies have shown that to obtain the required particle size, the RHA needs to be grown to size 45 µm – 10 µm.

C. Fly Ash

Fly ash used was obtained Koradi Power Plant Nagpur. Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of power generation facilities, whereas bottom ash is, as the name suggests, removed from the bottom of the furnace. In the past, fly ash was generally released into the atmosphere via the smoke stack, but pollution control equipment mandated in recent decades now require that it be captured prior to release. It is generally stored on site at most US electric power generation facilities. Depending upon the source and makeup of the coal being burned, the components of the fly ash produced vary considerably, but all fly ash includes substantial amounts of silica (silicon dioxide, SiO_2) (both amorphous and crystalline) and lime (calcium oxide, (CaO). Fly ash is commonly used to supplement Portland cement in concrete production, where it can bring both technological and economic benefits, and is increasingly finding use in synthesis of geopolymers and zeolites.

D. Aggregate

Good quality river sand was used as a fine aggregate. The fineness modulus, specific gravity and dry density are 2.32, 2.68 and 1690 kg/m3. Coarse aggregate passing through 20mm and retained 10mm sieve was used.Its specific gravity and dry density was 2.7 and 1550 kg/m3.

E. Chemical Admixture

A commercial AC- Green Slump-GS-02 black cat Chemical Limited and Glenium- AG-30 JP – BASF Const. Chemical Limited type hyper plasticizer was used to maintain the workability of fresh concrete. The dosage of hyper plasticizer was kept constant in mass

basis; it was 1%-1.6% of cement weight. The aim of keeping the amount of plasticizer constant is to neglect, if any, the influence of plasticizer on the properties of hardened concrete.

III. Experimental Programme

Experimental programme comprises of test on cement, RHA, FA, cement concrete with partial replacement of cement with RHA and FA.

A. RICE HUSK ASH

1) Normal Consistency = 17%

2) Initial and Final Setting time = 195min.

and 265min.

3) Compressive Strength = 11 N/mm^2

4) Specific Gravity = 2.09

B. ORDINARY PORTLAND CEMENT

OPC 43 grade cement is used for this whole experimental study. The physical test results on OPC are as follows.

1) Normal consistency = 22%

2) Initial Setting time = 30 min.

3) Final Setting Time = 10 hrs.

4) Specific Gravity = 3.15

C. TEST ON CONCRETE

An M25 mix is designed as per guidelines in IS 10262, 1982 based on the preliminary studies conducted in the constituent materials. Tests on fresh concrete are obtained as follows.

1) Slump Test=55mm

2) Vee-Bee = 13sec.

3) Compaction factor =0.95

4) Flow Test =78 %.

D. Mixture Proportioning

The mixture proportioning was done according the Indian Standard Recommended Method IS 10262-1982.The target mean strength was 32.1 Mpa for the OPC control mixture, the total binder content was 435.45 kg/m ,fine aggregate is taken 476kg/m and coarse aggregate is taken 1242.62kg/m the water to binder ratio was kept constant as 0.44, the Superplasticizer content was varied to maintain a slump of (200-240 mm) for all mixtures. The total mixing time was 5 minutes, the samples were then casted and left for 24 hrs before demoulding They were then placed in the curing tank until the day of testing Cement, sand, Fly ash, Rice husk ash and fine and coarse aggregate were properly mixed together in accordance with British Standard Code of Practice (BS 8110)19 in the ratio 1:1.1:2.85 by weight before water was added and was properly mixed together to achieve homogenous material. Water absorption capacity and moisture content were taken into consideration and appropriately subtracted from the water/cement ratio used for mixing. Muthadhi et al. 9 reported the blending of rice husk ash (RHA) in cement is recommended in most international building codes now. Hence, cement was replaced in percentages of 0, 1,2,3,4, 5 up to 30% with rice husk ash and fly ash and 150 × 150 × 150mm3, Beam and Cylinder moulds were used for casting. Compaction of concrete in three layers with 25 strokes of 16 mm rod was carried out for each layer. The concrete was left in the mould and allowed to set for 24 hours before the cubes were de moulded and placed in curing tank. The concrete cubes were cured in the tank for 7, 14, 28 and 90 days.

E. Testing methods

Testing is done as per following IS code. The testing done for compressive strength of cubes as per *IS : 516 – 1959* ,the testing done for flexural strength of beam as per *IS : 5816 - 1999* and the testing done for split tensile strength of cylinder as per *IS : 516 – 1959.*

Table No. 2 Table for compressive strength, Flexural strength, Split tensile strength

MIX			STRENGTH AFTER CURING IN DAYS in N/mm2					
SR.NO.	MIX PROPORTION		7DAYS	14 DAYS	28 DAYS	90 DAYS	FLEXURAL STRENGTH N/mm²	SPLIT TENSILE STRENGTH N/mm²
	FLYASH BY % CEMENT	RICE H. ASH BY %CEMENT						
1	**Control mix**		24.56	26.78	40.52	45.21	10.58	6.5
2	30	0	19.11	24.52	36	40.44	10.58	3.4
3	29	1	30.66	35.86	33.77	36.00	10	3.25
4	28	2	20	25.66	37.77	42.67	11	3.39
5	27	3	22.22	26.32	36	40.89	11.25	3.67
6	26	4	35.11	43.55	44	48.89	12	3.67
7	25	5	43.55	44	45	53.33	13.75	3.53
8	24	6	42.66	44	44	49.78	12.5	3.4
9	23	7	35.55	42.22	44.44	53.33	11.25	3.53
10	22	8	40.44	42.66	44.03	51.56	10.98	3.58
11	21	9	33.77	40.88	42.66	52.44	8.5	3.67
12	20	10	26.66	28.44	28.88	35.11	9.2	3.25
13	19	11	25.77	35.11	35.55	40.89	8.32	3.11
14	18	12	26.22	35.55	36	40.89	7.5	3.53
15	17	13	28.44	32	35.55	43.11	7.0	3.25
16	16	14	33.33	36	40	42.22	6.3	3.21
17	15	15	31.11	33.77	34.22	39.56	6.2	3.11
18	14	16	25.77	28	32	39.56	5.8	2.82
19	13	17	27.11	29.33	33.33	43.56	5.7	2.68
20	12	18	26.66	29.33	29.77	34.67	5.4	2.97
21	11	19	25.77	28.88	31.11	36.00	5.5	2.94
22	10	20	27.11	29.77	30.66	33.78	5.25	2.91
23	9	21	25.33	27.55	28.88	34.67	4.25	2.85
24	8	22	28.44	32	37.77	38.62	4.12	2.68
25	7	23	26.22	28.88	29.77	33.78	4.08	2.82
26	6	24	24.88	27.55	30.22	34.67	5.0	2.81
27	5	25	23.55	24.88	25.33	30.67	4.36	2.81
28	4	26	24.88	26.22	29.33	31.56	4.08	2.82
29	3	27	29.33	31.55	32.44	38.22	3.85	2.68
30	2	28	18.22	20.44	23.11	26.22	3.65	2.54
31	1	29	19.55	20.44	21.33	25.78	3.65	2.54
32	0	30	18.33	20	20.44	25.78	3.45	2.26

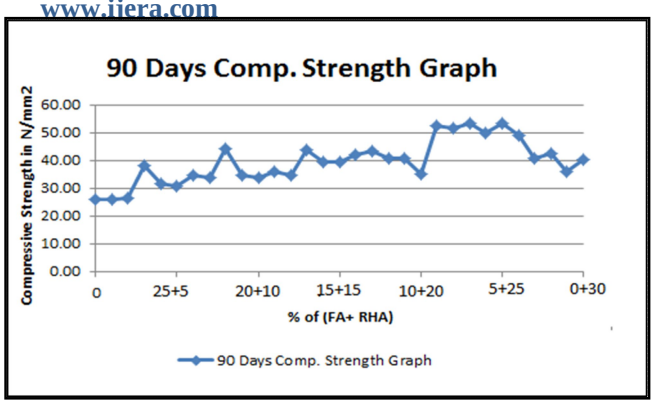


Fig. 1 Compressive Strength of Cubes at 90 Day

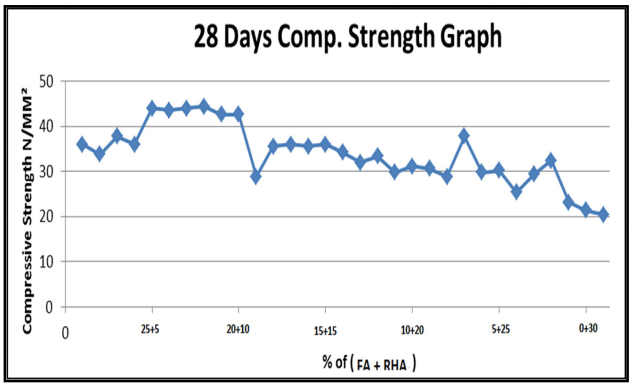


Fig.2 Compressive Strength of Cubes at 28 Day

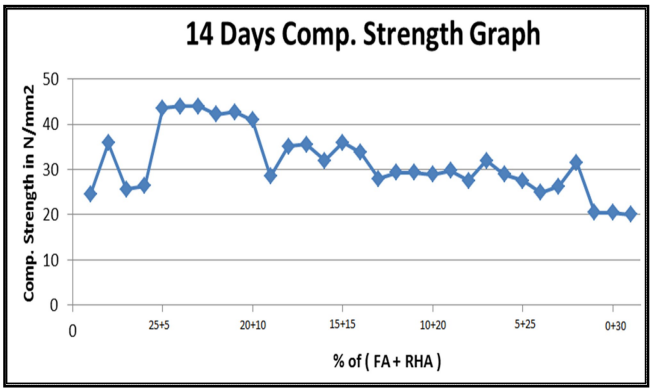


Fig. 3 Compressive Strength of Cubes at 14 Day

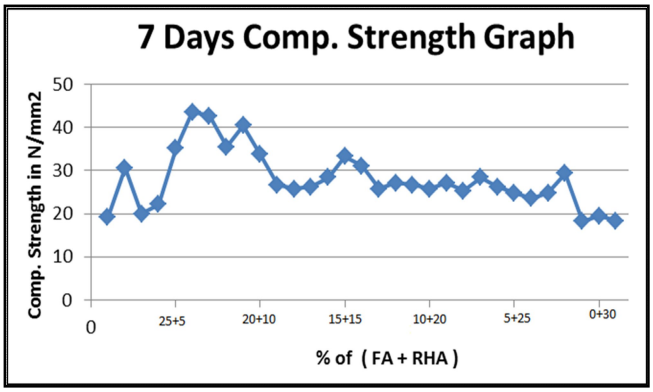


Fig. 4 Compressive Strength of Cubes at 7 Day

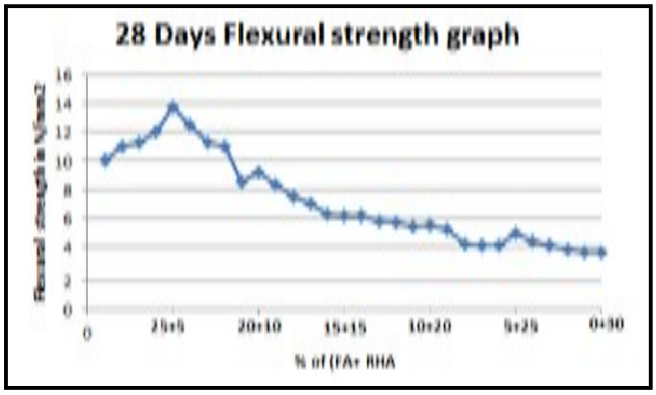


Fig. 5 Flexural Strength of Beams at 28 Day

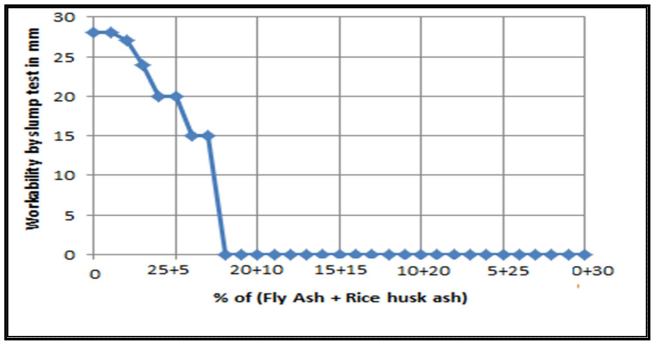
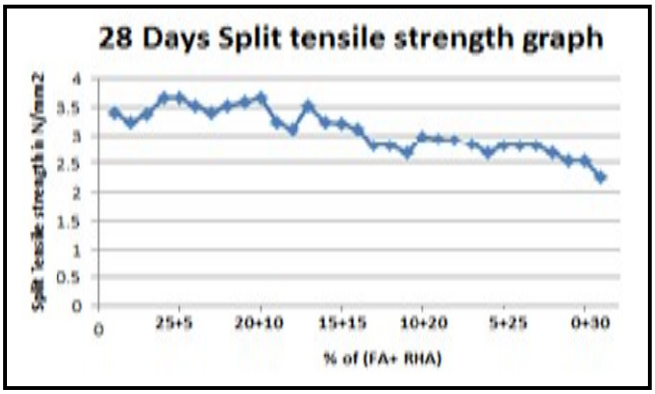


Fig. 7 Relation between Workability of concrete and % of

Fig. 6 Split Tensile Strength of Cylinders at 28 Days



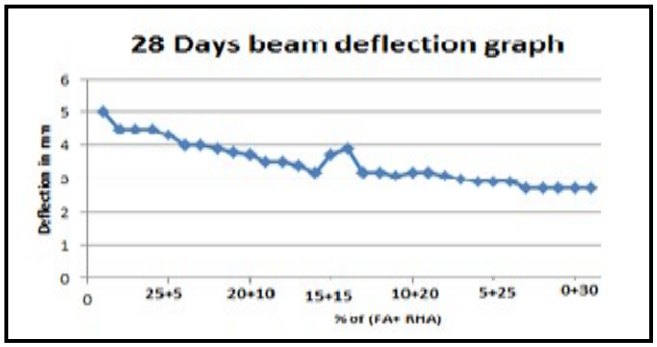


Fig.8 Relation between Deflection in mm and % of (FA+ RHA)

IV. METHODOLOGY OF INVESTIGATION

The data of 30 trials of mixes are used for the analysis. From the data of 30 trials with adding plasticizer equations are developed 'Multiple Regression and correlation Analysis' was applied to derive the equations. In Multiple Regression Analysis, various formulae were developed, by varying the input parameters to predict the 7, 14, 28 and 90 days strength of concrete cube. Selection of following equations with different inputs, which would help the user to predict the strength of concrete cube with available data / input parameters, is based on the results of analysis and the validation of formula.

EQUATION WITH PLASTICIZER

1) 28 Days' Strength Using Four Variables: (Sample No. 1-15)

STR28 = -0.170 x RHA + 74.364 x AD.WT. – 0.617 x AD.QU. – 1.202 x STR7 + 2.192 x STR14..... (1)

2) 28 Days' Strength Using Four Variables: (Sample No. 16-31)

STR14 = -0.111 x RHA + 2.245 x 10-3 x AD.QU. + 0.642 x STR7 + 0.453 x STR28..... (2)

Table 3: SUMMARY OF ACTUAL STRENGTH, PREDICTED STRENGTH WITH SUPERPLASTICIZER 28 DAYS' STRENGTH USING FOUR VARIABLES.

SR NO	PREDICTED STRENGTH in N/mm2	ACTUAL STRENGTH in N/mm2	DIFF.
1	30.77	36	-5.23
2	41.75	39.77	1.98
3	32.20	37.77	-5.57
4	33.15	36	-2.85
5	44.26	44	0.26
6	40.12	45	-4.88
7	38.50	44	-5.5
8	40.30	44.44	-4.14
9	36.22	44	-7.78
10	39.16	44	-4.84
11	27.29	28.88	-1.59
12	34.62	35.55	-0.93
13	35.88	40	-4.12
14	31.26	35.55	-4.29
15	32.98	36	-3.02

Table 4: SUMMARY OF ACTUAL STRENGTH, PREDICTED STRENGTH WITH SUPERPLASTICIZER 28 DAYS' STRENGTH USING FOUR VARIABLES.

SR NO	PREDICTED STRENGTH in N/mm2	ACTUAL STRENGTH in N/mm2	DIFF.
1	32.67	34.22	-1.55
2	27.56	32	-4.44
3	28.23	33.33	-5.1
4	28.40	29.77	-1.37
5	28.06	31.11	-3.05
6	28.60	30.66	-2.06
7	27.41	28.88	-1.47
8	33.28	37.77	-4.49
9	28.14	29.77	-1.63
10	27.31	30.22	-2.91
11	25.42	25.33	0.09
12	26.13	29.33	-3.2
13	30.55	32.44	-1.89
14	22.67	23.11	-0.44
15	22.37	21.33	1.04
16	22.11	20.44	1.67

V. Conclusions

Based on the results presented above, the following conclusions can be drawn:

1) Compressive strength increases with the increase in the percentage of Fly ash and Rice Husk Ash up to replacement (21%FA and 9% RHA) of Cement in Concrete for different mix proportions.
2) Concrete requires approximate increase in water cement ratio due to increase in percentage of RHA. Because RHA is highly porous material.
3) The workability of RHA concrete has been found to decrease with increase in RHA replacement.
4) It was found that rice husk when burned produced amount of silica (more than 80%). For this reason it provides excellent thermal insulation.
5) Rice husk ash contains more silica, and hence we prefer rice husk ash use in concrete than silica fume to increase the strength.
6) Through Rice husk ash is harmful for human being, but the cost of rice husk ash is zero and thus we prefer RHA use in concrete as compared to silica fumes.
7) The workability of RHA concrete has been found to decrease but FA increases the workability of concrete

so RHA and FA mix together in concrete to improve the workability of concrete.

8) Rice Husk Ash can be used with admixtures, plasticizers, and super plasticizers, for increasing the strength of concrete with partial replacement of cement.
9) In the presented work many factors are considered, which are believed to affect strength of concrete. **MULTIPLE REGRESSION ANALYSIS** is effectively used as a predictive tool.
10) Regression analysis as is well-known, gives explicit formula, which we can be directly used to predict the strength of concrete. Prediction of strength of concrete cube with regression analysis is easy and handy. The formulae can predict only 7 days, 14 days, 28 days and 90 days strength of the same concrete cube.
11) Present work is aimed at developing predictive tool with respect to normal density aggregate and normal weight concrete. However, the work can be extended to the concrete of light weight and heavy density
12) The maximum 90 days compressive strength was obtained with 23% fly ash 7% rice husk ash mix.
13) The maximum 28 days split tensile strength was obtained with 25% fly ash 5% rice husk ash mix.
14) The maximum 28 days flexural strength was obtained again with 25% fly ash and 5% rice husk ash mix.
15) The transition zone gets improved and densified with the use of ternary mix concretes containing rice husk ash and fly ash.
16) Due to the high specific surface area of the RHA, the dosage of superplasticizer had to be increased along with RHA fineness to maintain the desired workability.
17) The mechanical properties in terms of flexural and tensile strength have been significantly improved with the addition of RHA.
18) Rate analysis shows that as the percentage of RHA and FA added on the concrete the cost goes decrease up to 29%.
19) RHA when added in the concrete reduces the weight of the concrete up to 15% after 90 days of curing.

REFERENCES

1. D.V. Reddy, Ph. D, P.E. Professor

and Director of the Centre for Marine Structures & Geotechnique P.E, Department of Civil Engineering, Florida Atlantic University and Marcelina Alvarez, B.S. Structural Engineer, URS Corporation, Boca Raton developed "Marine Durability Characteristics of Rice Husk Ash Modified Reinforced Concrete".

2. **"**Rice Husk Ash – Properties and its Uses: A Review" by A. Muthadhi, R. Anita and Dr. S. Kothandaraman .
3. G. A. Habeeb, M. M. Fayyadh Department of Civil Engineering, Faculty of Engineering, University of Malaya, Malaysia developed "Rice Husk Ash Concrete: the Effect of RHA Average Particle Size on Mechanical Properties and Drying Shrinkage".
4. International Conference, Waste and Byproducts as Secondary Resources for Building Materials, 13-16 April, 1999, New Delhi, India.
5. IS 10262 -1981 "IS Method of Mix Design", Bureau of Indian Standards, New Delhi
6. IS 516 -1959 "Methods of Tests for strength of concrete", Bureau of Indian Standards, New Delhi
7. IS 456 -2000 "Code of Practice for Plain and Reinforced Concrete", Bureau of Indian Standards, New Delhi.
8. Shetty M. S. "Concrete Technology" S. Chand & Co.Ltd, 1997.
9. Alireza Naji Givi , Suraya Abdul Rashid , Farah Nora A. Aziz , Mohamad Amran Mohd Salleh developed "Contribution of Rice Husk Ash to the Properties of Mortar and Concrete:A Review".
10. Badorul Hisham Abu Bakar, Ramadhansyah PutrajayaC and Hamidi Abdulaziz developed "Malaysian Rice Husk Ash – Improving the Durabilityand Corrosion Resistance of Concrete: Pre-review".
11. A dimensional analysis method for predicting the 28-day compressive strength of 53-grade cements is presented in the paper by Dr. D. R. Pathak, N. P. Deshpande (J. Mat. in Civ. Engrg. (November/December 2005).
12. Dao Van Dong- Doctor, Pham Duy Huu- Professor, Nguyen Ngoc Lan- Engineer developed "Effect of rice husk ash on properties of high strength concrete".
13. **Dr** Kedar Mohan Paturkar developed "Effect of cement replacement by silica fume and fly ash

Books

1) M. S. Shetty, Concrete Technology, 5th ed., S.Chand & Co.Ltd, 2002.