ELSEVIER

Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 51 (2013) 35 – 44

Procedia Engineering

www.elsevier.com/locate/procedia

Chemical, Civil and Mechanical Engineering Track of 3rd Nirma University International Conference

Combine Effect of Rice Husk Ash and Fly Ash on Concrete by 30% Cement Replacement

Satish H. Sathawane[a*],Vikrant S. Vairagade[b] and Kavita S Kene[c]

[a,b]*Assistant Professor,Civil Engineering Dept, J L Chaturvedi College of Engineering,Nagpur,Maharashtra, INDIA*
[c]*Assistant Professor,Civil Engineering Dept, K. D. K. College of Engineering,Nagpur,Maharashtra, INDIA*

Abstract

In this paper, the detailed experimental investigation was done to study the effect of partial replacement of cement by Fly Ash (FA) and Rice Husk Ash (RHA) in combine proportion started from 30% FA and 0% RHA mix together in concrete by replacement of cement with the gradual increase of RHA by 2.5% and simultaneously gradual decrease of FA by 2.5%. Last proportion was taken 15%FA and 15% RHA. The tests on hardened concrete were destructive in nature which includes compressive test on cube for size (150 x 150 x 150 mm) at 7,14,28,56 and 90 days of curing as per IS: 516 – 1959, Flexural strength on beam (150 x 150 x700 mm) at 28 days of curing as per IS: 516 – 1959 and split tensile strength on cylinder (150 mm ø x 300mm) at 28 days of curing as per IS: 5816 – 1999. The work presented in this paper reports the effects on the behavior of concrete produced from cement with combination of FA and RHA at different proportions on the mechanical properties of concrete such as compressive strength, flexural strength, and split tensile strength. Investigation reported that compressive strength increases by 30.15% in compared with targeted strength and reduces by 8.73% compared with control concrete at 28 days, flexural strength increases by 4.57% compared with control concrete at 28 days, split tensile strength decreases by 9.58% compared with control concrete at 28 days, were obtained at combination of 22.5% FA and 7.5% RHA. Partial replacement of FA and RHA reduces the environmental effects, produces economical and eco-friendly concrete.

Keywords: Fly Ash, Rice husk Ash, Flexural Strength, Admixture, Compressive Strength, Split Tensile Strength

* Corresponding author. Tel.: +91-9860724462,
E-mail address: satish1816@gmail.com

doi:10.1016/j.proeng.2013.01.009

1. 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, and admixture to obtain concrete of desired property. The character of the concrete is determined by quality of the paste [7]. The key to achieving a strong, durable concrete rests in the careful proportioning, mixing and compacting of the ingredients.

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 artificial fibers are commonly used nowadays in order to improve the mechanical properties of concrete.[2] 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) with using Steel fiber 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. [1]

Over the past years, there has been an increasing number of papers on the use and utilization of industrial, agricultural and thermoelectric plants residue in the production of concrete. Different materials with pozzolanic properties such as fly ash, condensed silica fume, blast-furnace slag and rice husk ash have played an important part in the production of high performance concrete. During the late 20th century, there has been an increase in the consumption of mineral admixture by the cement and concrete is met by partial cement replacement [1]. Substantial energy and cost savings can result when industrial by-products are used as a partial replacement for the energy intensive Portland cement. Among the different existing residues and by products, the possibility of using rice husk ash in the production of structural concrete is very important for India. India is the second largest rice paddy cultivating country in the world. Both the technical advantages offered by structural concrete containing rice husk ash and the social benefits related to the decrease in number of problems of ash disposal in the environment have simulated the development of research into the potentialities of this material[5]. A large amount of agricultural waste was disposed in most of tropical countries especially in Asia for countries like India, Thailand, Philippine and Malaysia. If the waste cannot be disposed properly it will lead to social and environmental problem. Recycling of the disposed material is one method of treating the agricultural waste. The used of rice husk ash material in the formation of a composite material that can be used for construction. Rice husk ash is hazardous to environment if not dispose properly. [4]

This research paper deals with the study of effects on the behavior of concrete produced from partial replacement of cement with combination of FA and RHA at different proportions.

2. Materials and Methods

The work presented in this paper reports an investigation on the behaviour of concrete produced from partial replacement of 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 with target strength of 32.1 Mpa (M25) for the control mix. The effects of RHA and FA on concrete properties were studied by means of the mechanical properties of concrete i.e. compressive strength, split tensile strength, and flexural strength.

2.1 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 23 min and 365 min, respectively, conforming to I.S-8112- 1989. [13]

Table 1 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	2.0	3.71	3.0	1.74	0.80	0.96

Rice husk Ash	78.21	(SiO_2+ Al_2O_3+ Fe_2O_3) =82.64	0.99	4.89	--------	------	-------	-------

2.2 Rice Husk Ash

Rice husk ash used was obtained from Ellora Paper Plant located in Tumsar Bhandara, Nagpur, Maharashtra, India .The Specific gravity of rice husk ash is 2.14 and bulk density is 0.781 g/cc RHA, produced after burning of Rice husk (RH) has high reactivity and pozzolanic property. IS 456- 2000 [8], 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.

Table. 2 Physical properties of rice husk ash

Sr. No.	Test Conducted	Test Result	Requirement as per IS:3812 Part 1-2003
1	CONSISTANCY %	40.0	------
2	SPECIFIC GRAVITY(gm/cc)	2.14	------
3	SETTING TIME Initial(min.) Final(min)	 195 260	------
4	SOUNDNESS(mm) By Autoclave Expansion Method (%)	-0.0468	Max. 0.8
5	FINESS % by weight By sieving (% retention on 45 micron Sieve-wet sieving	29.3	Not more than 34
6	COMPRESSIVE STRENGTH (N/Sq.mm) 1) 7 DAYS 2) 28 DAYS	 15.0 27.0	Not less than 80%of cement at 28 days.
7	Drying Shrinkage (%)	0.0896	---------
8	Lime Reactivity(Kg/Sq.Cm)	26.93	Min.45

Fig 1: Rice Husk Ash

2.3 Fly Ash

Fly ash used was obtained Koradi Power Plant Nagpur, Nagpur, Maharashtra, India. 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.

2.4 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/m^3. Coarse aggregate passing through 20mm and retained 10mm sieve was used. Its specific gravity and dry density was 2.7 and 1550 kg/m^3.

2.5 Chemical Admixture

The main aim to used admixture was to maintain the workability of concrete with constant w/c by partial replacement of cement combination of FA and RHA. Due to high specific surface area of RHA which would increase the water demand, the experimental work need addition of super plasticizers. A commercial AC- Green Slump-GS-02B black cat Chemical Limited plasticizer from Nagpur, Maharashtra, India was used to maintain the workability of fresh concrete. The dosage of Super plasticizer was 1% to 1.5% by weight of cement of the binder content of concrete. This admixture benefits in increasing the workability without increasing the water/cement ratio and improve the cohesiveness and thereby reducing segregation or bleeding.

3. Experimental program

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

3.1 Rice Husk Ash

Rice Husk Ash was tested for different tests and test results as follows:

1) Normal Consistency = 17%
2) Initial and Final Setting time = 195 min. and 265 min.
3) Compressive Strength = 11 N/mm^2
4) Specific Gravity = 2.14

3.2 Ordinary Portland Cement

OPC 43 grade cement is used for this whole experimental study.
Ordinary Portland cement of 43 grade were tested for different tests and physical test results on OPC were as follows:
1) Normal consistency = 22%
2) Initial Setting time = 23 min.
3) Final Setting Time = 365 min.
4) Specific Gravity = 3.15

3.3 Mixture Proportioning

The mix proportion was done as per the IS 10262- 1982[9]. The target mean strength was 32.1 Mpa (M25) for the OPC control mixture, the total binder content was 435.45 kg/m^3, fine aggregate was taken 476kg/m^3 and coarse aggregate was taken 1242.62 kg/m^3. The water to binder ratio was kept constant as 0.44, the Super plasticizer content was varied to maintain a slump 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 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 reported the blending of rice husk ash (RHA) in cement is recommended in most international building codes now. Hence, cement was replaced in 30% with rice husk ash and fly ash and Cube, 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, 56 and 90 days for compression test.

Mix proportion for M25 grade concrete for tested material as follows:

Table 3: Concrete mix proportions

MATERIAL	QUANTITY	PROPORTION
Cement	435.45 Kg/ m^3	1
Sand	476 Kg/ m^3	1.1
Coarse Aggregates	1242.62 Kg/ m^3	2.85
Water	191.6 Kg/ m^3	0.44
Slump	75-100 mm	-----

3.4 Different Proportion of Cement, Rice Husk Ask and Fly ash for testing:

In this experimentation, cement was partially replaced by combinations of Rice Husk Ash (RHA) and Fly ash (FA). Test was started with control concrete of M25 grade. Then, replaced the 30 % cement with RHA and FA, by increasing the 2.5% of RHA up to 15% and adding corresponding percentage of Fly ash.
Following table shows the percentage variations of cement, fly ash and rice husk ash.

Table 4: Proportion of Cement, Rice Husk Ask and Fly ash for testing

Sr. No	% of Cement	% of FlyAsh	% of RHA
1	100%	0%	0%
2	70%	30%	0%
3	70%	27.5%	2.5%
4	70%	25%	5%
5	70%	22.5%	7.5%
6	70%	20%	10%
7	70%	17.5%	12.5%
8	70%	15%	15%

4. Experimental Methodology

4.1 Test on Fresh Concrete

Fresh concrete was tested using slump cone test to find the workability of control concrete and concrete of combination of FA and RHA with partial replacement of cement.

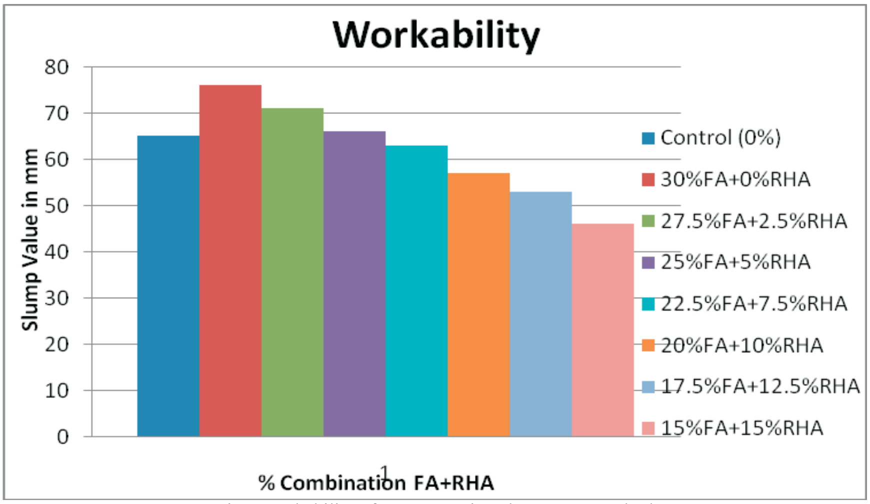

Fig.2 Workability of concrete using slump cone method

Figure2 shows the comparative effects of addition of FA and RHA on workability of concrete. It was observed that FA increases the workability of concrete upto 16.92 % as compared to control concrete. Gradual increase of RHA and gradual decrease FA shows gradual decrease in workability upto 29.23% as compared to compared concrete.
Addition of FA increases in workability because it has very low binding property and addition of RHA decreases workability due to water absorbent property because it has high specific surface area.

4.2 Test on Harden Concrete

Tests were done as per following codes of Bureau of Indian Standards. The test for compressive strength on cubes were measured at 7, 14, 28, 56 and 90 days of curing as per IS : 516 – 1959[14], test for flexural strength on beam was measured at 28 days of curing as per IS : 516 – 1959 [12] and test for split tensile strength on cylinder was measured at 28 days of curing as per IS : 5816 – 1999[14].

4.3 Compressive Strength Test

For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm were cast for M25 grade of concrete. The moulds were filled with different proportions of cement, Rice Husk Ash and Fly Ash. Vibration was given to the moulds using table vibrator. The top surface of the specimen was leveled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank where in they were allowed to cure for 7,14,28,56 and 90 days. After 7,14,28,56 and 90 days curing, these cubes were tested on digital compression testing machine as per I.S. 516-1959[14]. The failure load was noted. In each category, three cubes were tested and their average value is reported.

The compressive strength was calculated as follows:
Compressive strength (MPa) = Failure load / cross sectional area.


Fig 3 Testing of specimen under compression

4.4 Tensile strength test

For tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 28 days. These specimens were tested under compression testing machine. In each category, three cylinders were tested and their average value was reported.
Tensile strength was calculated as follows as split tensile strength:
Tensile strength (MPa) = 2P / π DL, Where, P = failure load, D = diameter of cylinder, L = length of cylinder.


Fig 4 Testing of specimen under split tension

4.5 Flexural Strength Test

The standard sizes of beam specimen were 15x15x70 cm. The beam moulds conform to IS:10086-1982. Compacting of concrete will be done by vibration as per IS: 516-1959. Curing: Test specimens shall be stored in water at a temperature of 24^0-34^0c for 48 hours before testing. The specimens shall be tested immediately on removal from the water while they are still in the wet condition. The Flexure test was performed on two point loading system.

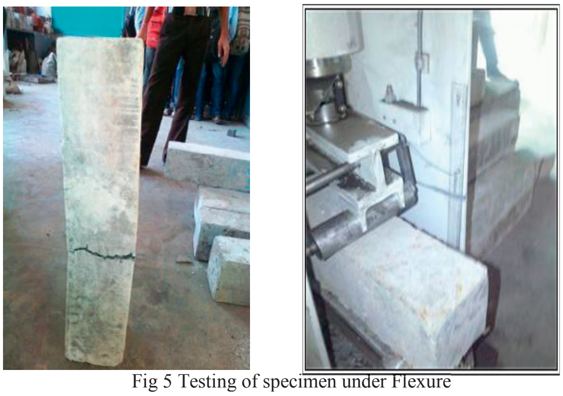

Fig 5 Testing of specimen under Flexure

5. Experimental Results

Results of M25 grade of OPC concrete filled with various proportions of Rice Husk Ash and Fly Ash for compressive strength, split tensile strength also for flexural strength test are shown in table below.

5.1 Results of Compressive Strength

Table 5: Results of Compressive strength with different % of FA+RHA

Sr. No.	Mix Proportion		Compressive Strength after No of Days of curing in N/mm^2				
	FA by% of cement	RHA by% of cement	7 Days	14 Days	28 Days	56 Days	90 Days
1	Control Mix		35.56	39.11	45.78	48	49.78
2	30	0	32.89	33.33	39.11	42.22	44.89
3	27.5	2.5	31.11	31.33	35.11	37.33	39.56
4	25	5	31.56	32.44	40.44	43.11	45.78
5	**22.5**	**7.5**	**22.67**	**34.67**	**41.78**	**44.89**	**46.67**
6	20	10	22.22	26.22	33.78	35.11	37.78
7	17.5	12.5	18.22	24.89	33.78	32.00	34.67
8	15	15	17.78	24.00	28.89	30.67	33.78

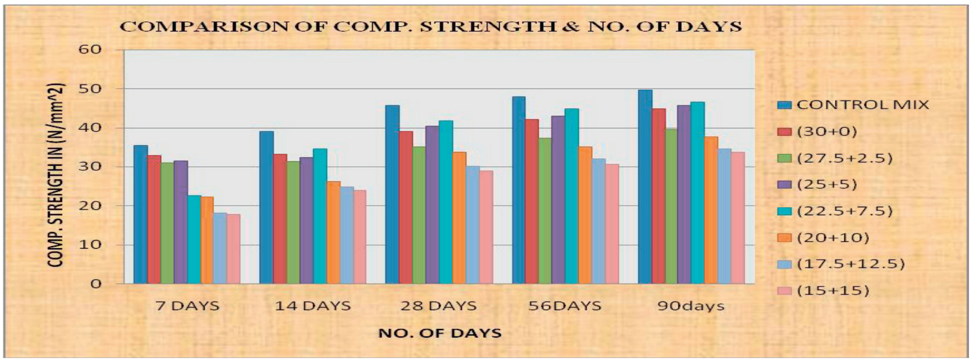

Fig 6. Comparison of compressive strength for different % of RHA and FA

Figure 6 indicates 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.

5.2 Results of Flexural Strength on Beams (As per IS: 516 – 1959)

Table 6: Results of flexural strength with different % of FA+RHA

Sr. No.	Mix Proportion		Flexural strength after 28 days curing in N/mm^2
	FA by% of cement	RHA by% of cement	
1	Control Mix		7.22
2	30	0	6.89
3	27.5	2.5	6.11
4	25	5	6.44
5	22.5	7.5	7.55
6	20	10	6.22
7	17.5	12.5	5.55
8	15	15	5.55

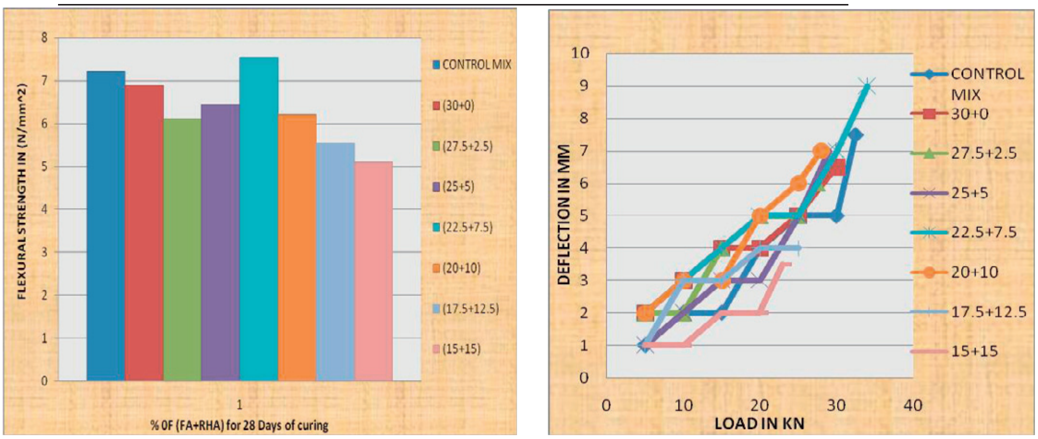

Fig 7 Comparison of flexural strength for different % of RHA and FA at 28 days of curing and deflection of beam

Figure 7 indicates the comparison of results of flexural tensile strength using beam specimens of M25 grade of concrete. Beams were tested after 28 days of curing for Flexural Strength. 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.

5.3 Results of Split Tensile Strength (As per IS: 5816 – 1999)

Table 7: Results of Split Tensile strength with different % of FA+RHA at 28 days of curing

Sr. No.	Mix Proportion		Split tensile strength after 28 days curing in N/mm2
	FA by% of cement	RHA by% of cement	
1	Control Mix		4.38
2	30	0	4.10
3	27.5	2.5	3.82
4	25	5	3.67
5	22.5	7.5	3.96
6	20	10	2.97
7	17.5	12.5	2.26
8	15	15	1.98

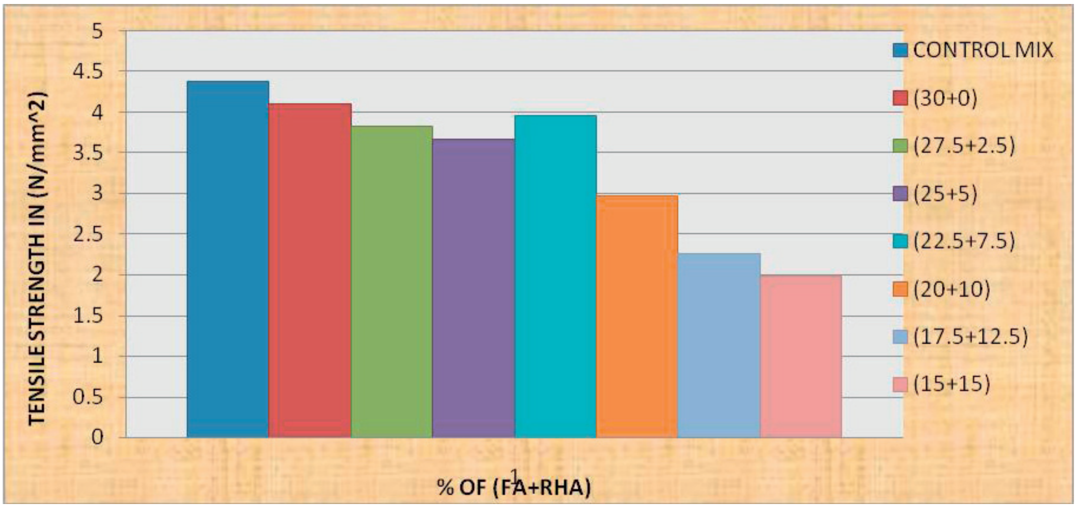

Fig 8. Comparison of split tensile strength for different % of RHA and FA at 28 days of curing

Figure 8 indicates the comparison of results of splitting tensile strength using cylindrical specimens of M25 grade of concrete. It was observed that split tensile strength at the combination of 22.5% FA and 7.5% RHA decreases by 9.58% as compared to control concrete at 28 days of curing.

6. Conclusions

Fly ash and Rice husk ash is found to be superior to other supplementary materials like slag, and silica fume. RHA used in this study is efficient as a pozzolanic material; it is reach in amorphous silica. Due to low specific gravity of RHA which leads to reduction in mass per unit volume, thus adding it reduces the dead load on the structure. Used of Fly ash and Rice husk ash helps in reducing the environment pollution during the disposal of excess Fly ash and Rice husk ash. Cement is costly material, so the partial replacements of these materials by Rice husk ash reduces the cost of concrete.

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 (22.5%FA and 7.5% RHA) of Cement in Concrete for different mix proportions.
2. The maximum 28 days split tensile strength was obtained with combination of 22.5% Fly ash and 7.5% rice husk ash mix in all combinations which was less than control concrete.
3. The maximum 28 days flexural strength was obtained with combination of 22.5% fly ash and 7.5% rice husk ash mix.
4. The percentage of water cement ratio is reliant on quantity of RHA used in concrete. Because RHA is a highly porous material
5. The workability of concrete had been found to be decrease with increase RHA in concrete .

References

[1] Dale P. Bentz, Max A. Peltz, John Winpigler 2009, The influence of water-to-cement mass ratio (w/c) on early-age properties of cement-based materials is investigated using a variety of experimental techniques. ASCE Journal of Materials in Civil Engineering, 21 (9), 512-517, 2009
[2] Dao Van Dong, Pham Duy Huu, Nguyen Ngoc Lan, 2008, "Effect of rice husk ash on properties of high strength concrete". The 3rd ACF International Conference, 2008
[3] Muhammad Harunur Rashid, Md. Keramat Ali Molla, TarifUddin Ahmed, 2010, Mortar Incorporating Rice Husk Ash: Strength and Porosity Journal of Scientific Research, EuroJournals Publishing, Vol.40 No.3 (2010), pp.471-477
[4] Alireza Naji Givi ,Suraya Abdul Rashid , Farah Nora A. Aziz , Mohamad Amran Mohd Salleh, 2010, "Contribution of Rice Husk Ash to the Properties of Mortar and Concrete:A Review" Journal of American Science 2010;6(3)
[5] Muthadhi A, Anitha R. Kothandaraman S, 2007, Rice Husk Ash – Properties and its uses: A Review, Journal CV Vol 88, May 2007
[6] Reddy D.V. 2006, Marine Durability "Characteristics of Rice Husk Ash- Modified Reinforced Concrete" Fourth LACCEI International Latin American and Caribbean Conference for Engineering and Technology (LACCET'2006) June 2006, Mayagüez, Puerto Rico.
[7] Pathak D. R., Deshpande N. P., 2005, "A dimensional analysis method for predicting the 28-day compressive strength of 53-grade cements" Journal of Materials in Civil Engineering, Volume 17, Issue 6, December 2005
[8] IS 456-2000, Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standards, New Delhi, India
[9] IS 10262-1982, Recommended Guidelines for Concrete Mix Design, Bureau of Indian Standards, New Delhi, India
[10] IS 383:1970, Specification for coarse and fine aggregates from natural sources for concrete (second revision), Bureau of Indian standards, New Delhi,

India.
[11] IS 1199-1959, Methods of Sampling and Analysis of Concrete, Bureau of Indian Standards, New Delhi, India
[12] IS 5816-1999, Method of Test for Splitting Tensile Strength of Concrete., Bureau of Indian Standards, New Delhi, India
[13] IS 8112:1989, 43 Grade Ordinary Portland Cement – Specification (First Revision), IS 8112:1989, Bureau of Indian Standards, New Delhi.
[14] IS: 516-1959, Indian standard methods of tests for strength of concrete, Bureau of Indian Standards, New Delhi, India
[15] IS 1489(Part-I)-1991, Portland - Pozzolana Cement Specification, Bureau of Indian Standards, New Delhi, India