Study on Rice Husk Ash as a Partial Replacement of PPC Cement (Fly Ash based) in Concrete

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Abstract— Different materials with pozzolanic properties such as fly ash. Condensed silica fume, blast furnace slag and rice husk ash have played an important role in the production of high performance concrete. During the late 20th century, there has been an increment in the use of mineral admixture by the cement and concrete industries.The increasing need for cement and concrete is filled by the partial replacement for energy intensive Portland cement. Pozzolanic materials have long proven their strength in developing high performance concrete. Artificial pozzolanas such as supplementary cementing material in many sections of the globe.This work evaluates the compressive strength of rice husk ash (RHA) as a partial replacement for PPC in concrete.The main objective of this study is to find the optimum % (0, 8, 10, 12, 14, 16) of (RHA) as partial replacement of cement for M35 grade of concrete. And also effect of super plasticizer on mechanical properties. In addition, results show that RHA as an artificial pozzolanic material has enhanced the durability of RHA concrete.

Key words: Rice husk ash (RHA), cement replacement, concrete durability, workability and durability

I. INTRODUCTION

Rice straw is one of the most widely available agricultural wastes in many rice growing nations around the globe. Globally, approximately 600 million loads of rice paddy are produced each year. On average, 20% of the rice paddy is husked, giving an annual total production of 120 million tons [1]. In majority of rice producing countries much of the husk produced from processing of rice is either burnt or dumped as waste [2]. Burning of RH in ambient atmosphere leaves a residue, called rice husk ash. For every 1000 kg of paddy milled, about 220 kgs (22 %) of the husk are produced, and when this husk is burnt in the boilers, about 55 kgs (25 %) of RHA is generated [3]. Rice husk removal during rice refining, creates a disposal problem due to less commercial interest. Also, handling and transportation of RH are problematic due to its low density. RHA is a big environmental threat causing damage to land and the surrounding country where it is dumped. Thus, commercial usage of rice straw and its ash is the alternative solution to disposal problem. In this paper we have hashed out a preliminary analysis of the numerous reported properties and purposes of rice straw and its ash. An effort has been made to accumulate data and information from diverse research work connected to RH and RHA.

II. EXPERIMENTAL PROGRAM

A. Materials Used

1) Cement:

Pozzolanic Portland cement (PPC) conforming to IS: 1489 (Part1) -1991. With specific gravity 3.15

2) Fine Aggregate:

Natural river sand conforming to Zone II as per IS 383 (1987) was used. The fineness modulus of sand used is 2.64 with a specific gravity of 2.6.

3) Coarse Aggregate*:*

Crushed granite coarse aggregate conforming to IS: 383 (1987) was employed. Coarse aggregate of size 20 mm down having the specific gravity of 2.8 and fineness modulus of 7.20 was applied.

4) Rice Husk Ash:

Commercially available rice husk ash was procured and used in the experimental investigation Physical and Chemical proper- ties of rice husk ash obtained from Bhargav krisi farm Jijajipur Vidisha, Madhaya Pradesh, India. The ground ash was removed for chemical and physical exams to break on its performance as a pozzolanic material.

5) Superplasticizers:

During this investigation Sulphonated Naphthalene (SNF) based Super Plasticizer (SP) was applied. The super plasticizers used for the survey conforms to IS 9103 (1999).

B. Mix Proportion

The mixture proportions for the controlled concrete of M35 grade were arrived at from the trail mixes. Concrete mix of M35 grade was designed as per specification of IS 10262 : 2009, for water cement ratio 0.43. In this method, five replacements of cement i.e. 8%, 10%, 12%, 14%, 16% say CC, CC1, CC2, CC3, CC4, CC5 respectively, with rice husk ash (RHA) are executed, whereas the total binder content remains the same.

The mix proportions considered for each replacement by replacement method with RHA are presented in the table 1 below:

% Replacement	**Concrete grade**	**Cement (kgs)**	**Rice husk (kgs)**	**Fine aggregate (kgs)**	**Coarse aggregate (kgs)**	**Water (In Liter)**	**Super plasticizer (In Liter)**
8% Replacement	M35	0.92	0.08	1.6	2.1	0.43	0.003
	In m^3	368	32	642	1165	192	
10%	M35	0.9	0.	1.6	2.1	0.4	0.003

Replacement			1			3	5
	In m^3	360	40	642	1165	192	
12% Replacement	M35	0.88	0.12	1.6	2.1	0.43	0.004
	In m^3	352	48	642	1165	192	
14% Replacement	M35	0.86	0.14	1.6	2.1	43	0.0045
	In m^3	344	56	642	1165	192	
16% Replacement	M35	0.84	0.16	1.6	2.1	0.43	0.005
	In m^3	336	64	642	1165	192	

Table 1: Mix Proportion of RHA mix

C. Preparation of Test Specimen

The ingredients for various mixes were weighed; required water was added and mixed by using a tilting drum type concrete mixing machine. Precautions were taken to ensure uniform mixing of components. The specimens were cast in steel mould and com- pacted on a table vibrator. The specimens of 15cm × 15 cm× 15 cm size of cubes were put as per Indian standard IS: 516 (1959) according to which it is the size to be used for coarse aggregate size of up to 20 mm for the determination of compressive force at different ages and for the durability properties. Healing of the specimens was started as soon as the top surface of the concrete in the mold was hard enough. Spreading wet gunny bags over the mold for 24 hours after the casting was carried away in the initial healing. The specimens were later demoulded and placed immediately in water tank for further curing.

D. Curing:

Healing of the specimen done as per IS 516 : 1959, The test specimen shall be stored on the site at a place free from vibration, under damp matting, sacks or other similar material for 24 hours +- ½ hour from the time of adding the water to the other components. The temperature of the place of storage shall be inside the range of 22^o to 32^o C. After the period of 24 hours, they shall be noted for later identification, taken away from the molds and, unless required for testing within 24 hours, stored in clear water at a temperature of 24^o to 30^oC until they are sent to the testing lab. They shall be committed to the testing laboratory well packed in damp sand, damp socks, or other suitable material so as to arrive there in a damp condition not less than 24 hours before the time of the trial. On arrival at the testing laboratory, the specimen shall be stored in water at a temperature of 27^o+- 2^oC until the time of the trial. A platter of the daily maximum and minimum temperature shall be kept both during the menstruation of the specimen remain on the website and in the laboratory, and test conducted for the specimen after 7, 14 and 28 days.

E. Test Conducted

1) Compressive Strength

The compressive strength of RHA cement was determined using 150mm concrete cubes. The cement component was made by replacing 8,10,12,14 and 16% of pozzolana Portland cement (PPC) for one set of sample cubes. Also standard mortar cubes and concrete cubes without RHA were cast in comparison. For mortar cubes 1 part of cement was mixed with 3 parts of sand. For concrete cubes a ratio of 1:1.6:2.907 for cement: sand: aggregate by weight was used. Approximately 45 concrete cubes and 45 concrete cubes were built with standard sand and well-graded aggregates, mixed by a mechanical mixer and compacted by means of the standard vibration machine. The cubes were cured and crushed for compressive strength for each mixture at different curing periods. Compressive strength results of mortar PPC/RHA in N/mm^2

2) Workability

Slump test was used to check on the result of rice husk ash on the workability of concrete. The concrete was produced with different portions of rice husk ash mixed with PPC.

3) Slump Cone Test

A mold in the form of a frustum of cone 300mm high, base diameter of 200mm and a top opening diameter of 100mm was used. The cast was set on a tranquil open and filled with concrete in three layers, each layer being tamped 25 times with a standard 16mm diameter steel pole. The excess concrete at the top surface was scratched off and the surface leveled by rolling the tamping rod. The cone was then slowly arose, and the unsupported concrete allowed to sink. The drop-off in the pinnacle of the slumped concrete is recorded as slump in millimeters. This process was repeated for concrete with different portions of rice husk ash.

4) Standard Consistency

The quantity of water required to give an RHA cement paste of standard consistence was determined by using the Vicat Apparatus. This quantity of water breaks the urine capacity of the past for determination of setting times. Sample mixes of about 300g made from RHA and PPC at various percentages were weighed. For each sample a known amount of water is added and mixed thoroughly for approximately 5 minutes along a non-porous surface by way of two trowels avoiding loss of water or cement. The paste was transferred directly to the mildew of the Vicat Apparatus, which had previously been located on a lightly greased plane glass base-shell, and occupied in excess without compacting or vibrating. The excess material was removed by a gentle sawing motion with a straight edge. The Vicat apparatus was calibrated with the plunger by lowering the plunger to rest on the base plate to be used and adjusting the arrow to read zero on the weighing machine. The plunger was raised to the standby position. Immediately after leveling the paste, the oral cavity and the root-plate was changed to the Vicat Apparatus and positioned centrally under the piston. The diver was lowered gently until it was in contact with the paste. The plunger was allowed to pause in this place for two minutes in order to avoid initial velocity. The moving parts were then quickly released and the plunger allowed to penetrate vertically into the center of the paste. The plate was read when penetration ceased. The recorded scale reading indicates the space between the bottom face of the piston and the root-shell. The water content of the paste was determined which is expressed as a percentage by mass of the RHA cement. The plunger was cleaned and the procedure repeated with pastes containing different water contents until one was set up to create a distance between plunger and foot-plate of 6mm. The water content of this station was calculated as a part of the volume of the dry rice husk ash cement and recorded as water taken for standard consistence. Table 12 indicates the sum of water called for when the RHA in the mix is changed.

5) Setting Time

The setting time test was extended out in accordance with the Indian Standard on concrete with PPC/RHA mixes at standard consistence.

III. Result and Discussion

A. Standard consistence

The increased need for water prompted standard consistence test to be performed. The outcomes were subsequently employed in setting time test. The increase fines in the concrete due to excess RHA is partly responsible for this increased demand for water. The strength loss caused by the high specific surface area of micro-silica can be overcome by adding suitable water reducer to the mixture. Table no. 2 and in figure 1 indicates the amount of water required for a standard consistent concrete mix. The result show increase water demand as % RHA is increased. This corroborates the other findings on workability. But since increase water/cement ratio reduces strength of concrete. Optimum water content should be shown so that the potency is not compromised.

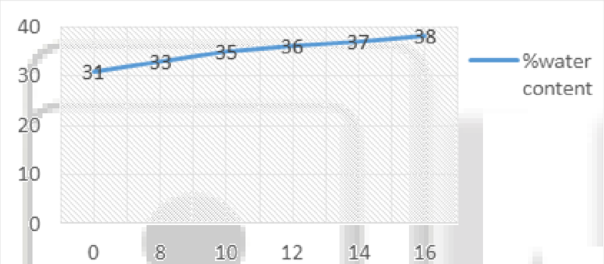

Fig. no. 1 Required Water content for standard Consistency of RHA mix

RHA: PPC	0:100	8:92	10:90	12:88	14:86	16:84
Water content for standard Cconsistence %	31	33	35	36	37	38

Table No. 2 Required Water content for standard Consistency of RHA mix

B. Setting time

The effect of RHA othe setting timeme of concrete with OPC/RHA mix is shown in table no. 4; final setting time and initial setting time in figure no. 3 and figure no. 2. The setting times were found to increase with increase amounts of RHA. The reaction between cement and water is exothermic. The liberation of heat and evaporation of moisture causes the stiffening of the past and slower heat induced evaporation of water from the cement/ RHA paste due to its lower cement content and therefore accelerated increase in initial setting time and final setting time of mixtures. [48]

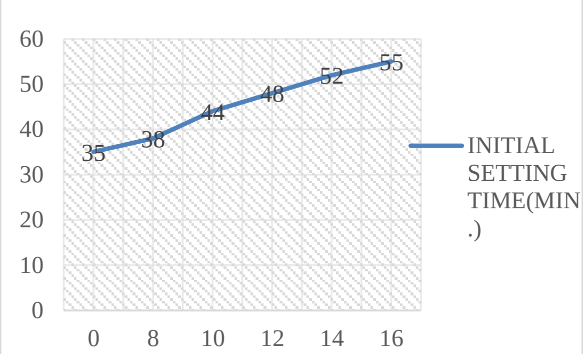

Fig no. 2 Intial Setting time of RHA mix

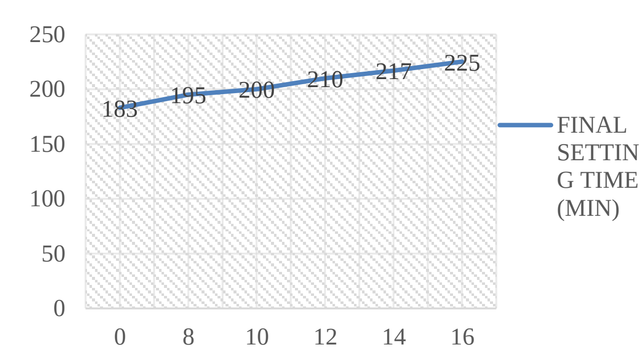

Fig no. 3 Final Setting Time of RHA mix

Name	Mix ratio RHA: PPC	Slump (mm)
CC	0:100	42.5
CC1	8:92	32
CC2	10:90	20
CC3	12:88	10
CC4	14:86	5
CC5	16:94	4

Table no. 3 Workability of RHA mix

Mix	Mix ratio	Setting times (Min.)	
	RHA: PPC	Initial	Final
CC	0:100	35	183
CC1	8:92	38	195
CC2	10:90	44	200
CC3	12:88	48	210
CC4	14:86	52	217
CC5	16:84	55	225

Table 4: Setting time of RHA mix

Curing Days	Decrease in Percentage of Strength of Concrete				
	CC1 (8% RHA)	CC2 (10% RHA)	CC3 (12% RHA)	CC4 (14% RHA)	CC5 (16% RHA)
7 Days	-25	-6	-17	-36	-41
14Days	-16	-12	-13	-34	-38
28Days	-8	-3	-7	-35	-37

Table 6: Decrease in the percentage of Compressive Strength of RHA mix

C. Workability

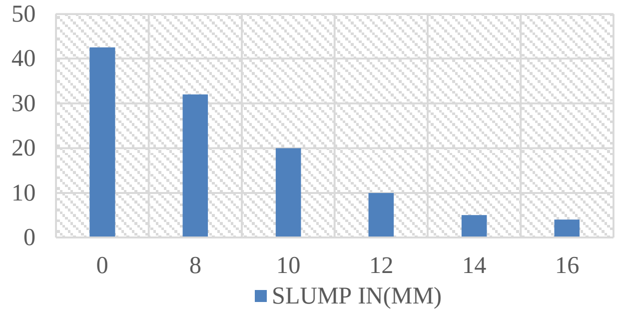

Fig no.4
Effect of RHA on workability of concrete

The strength of pozzolanic and pozzolana cements depends on the characteristics of the porcelain used. The effect of RHA on the workability of concrete as indicated by the concrete slump is shown in table 3 and in figure 4.The graph shows the concrete slump value decreases with increases amount of RHA. This is because of the addition of relatively high amounts of silica to pozzolana cement increases the water demand remarkably; it reduces workability and the strength of the mixes. The negative influence of very fine silica on strength has also been observed in pastes containing a special amount of colloidal silica [4]. This signifies that a less workable (Stiff) mix is obtained when RHA is used as a cement blender. More water is therefore commanded to produce a viable mixture. The increase fines in the concrete due to excess RHA is partly responsible for this increased demand for water. [5] The strength loss caused by the high specific surface area of micro-silica can be overcome by adding suitable water reducer to the mixture. [4] So the addition of super plasticizer increased the 28 days strength of standard mortars by 35-80 %.

D. Compressive strength

Most concrete structures are designed assuming that concrete processes sufficient compressive force, merely not the tensile force. The compressive strength is the primary standard for the use of structural design. To examine the strength development of rice husk ash (RHA) concrete in comparison to control concrete. Effects of compressive strength of concrete are given in table 5 and in Figure 5. Compressive strength tests were taken at the ages of 7, 14, 28 days. The trial outcomes are reported in table 5 for control concrete are in the table for RHA concrete respectively. In this study, RHA was used as pozzolanic material in combination with cement. pozzolans contain significant amounts of silicates. From the results it is found that the compressive strength of the products involving RHA for the different curing period was more eminent than the compressive strength of the products without RHA for same curing periods. Maximum strength for the compositions i.e. cc1, cc2, cc3, cc4, cc5 was obtained after 28 days curing. Even after 7 days of curing the strength was obtained near to that of conventional concrete. The main factor responsible for improvement in compressive strength is the chemical hydration [6,7]. Since RHA is patently hydraulic and undergoes hydration reactions in the presence of urine and calcium hydroxide, this secondary pozzolanic reaction yields a denser microstructure because the CA (OH) 2 is consumed and CSH paste is formed [8,9]. Another factor which leads to an increase in strength development is due to heterogeneous nucleation. This procedure enhances the chemical activation of the hydration of cement. Therefore, increasing the quantity of the mineral admixture and refining its particle size will promote heterogeneous nucleation due to availability of sites [6,10]. Compressive strength gain of composites has been assigned to the hydration and porosity [11]. Availability of purer water for the hydration reaction also increases the compressive force. Initially, the granulated RHA in contact with water react very fast and the hydration ceases because of the constitution of a flimsy layer of silica rich gel over the airfoil. In the bearing of an activator (cement), the structure of the gel is broken down and products similar to the one obtained hydration of pozzolana Portland cement are formed. [12]. The value of compressive strength increases via the dynamic generation and submission of aluminate hydrates. The other imported factor which aids in increasing the potency development is formed of alunimo-ferrite-tricalciumsulfate and alunimo-ferrite-monocalciumsulfate. The hardened structure filled the mocropores thereby densifying the structure, formation of calcium-silicate-hydrate, calcium alumonate-hydration reaction provides strength. RHA contains SiO_2, Al_2O_3 and Fe_2O_3 which undergo upon addition of water to generate phases similar to those found in cement based systems [43] From the table no. 16 it is revealed that minimum compressive strength of 18.22 N/mm2 was found with 16% RHA and 84 % cement after 7 days of curing. Further decreased in concentration of the RHA with cement the compressive strength increased. The increase in strength may be due to the contribution of pozzolanic activity of RHA. This indicated that the chemical elements present in the RHA are important elements, which significantly contributed to attain strength of 25.78 N/mm2. After 14 days of curing the compressive strength of RHA product was found to measure the effectiveness. The composition with 16% RHA showed the minimum intensity level of 20 N/mm2 while maximum strength of 28.44 N/mm2 was obtained with a quantity of RHA (10%). The compressive strength after 28 days of curing was found to be maximum when compared with the effectiveness of the products obtained after 7days and 14 days curing. From the results it is revealed that the maximum strength of 39.11 N/mm2 was obtained with 10% RHA. After 28 days of bringing around the hydration reaction is completed resulting in the composition of the product and thereby increasing the force. The varying trends of the intensity of the RHA product after curing 7,14,28 days are shown in fig. no.19. Percentage increase in strength with respect to control concrete strength (i.e. 0% replacement) at 7 days, 14 days, 28 days are calculated and presented in table. From table no. 7 the change in strength for M35 grade RHA concrete is presented on an individual basis and the following observations are created, the maximum increase in the compressive strength of RHA concrete i.e., 37.52% has occurred at 28 days with 10 % replacement, whereas the compressive strength of RHA concrete is ground to be decreased by 9.05% at 7 days with 14% RHA replacement. It can be clearly noticed that at the age of 28 days, there is gradual increase in the compressive strength of RHA concrete for all the replacement levels with regard to control concrete. Strength development of concrete for different percentage replacements with RHA is presented in table 17 to19. In each table, by what percentage the compressive strength increases with regard to old years is reported.

From the above table it can be clearly experienced that, the strength is higher for control concrete (i.e. 0% replacement) for an initial period up to between 7-14 days up to 10% replacement with Rice husk ash, and for 12% replacement with RHA, the intensity level is approximate same when compared to that of control concrete. The rate of strength development between 14-28 days is maximum when cement is replaced with 10% RHA. So, from the above table it is clear that the rate of intensity development is maximum up to the age of 28 days at all the replacement levels with RHA.

IV. Effect of Percentage Replacement of Cement with Rice Husk Ash (RHA) on Compressive Strength of Concrete

Figure no. 6 stands for the variation of compressive strength with the percentage Replacement of RHA for M35 grade concrete. Comparing between different replacements is made possible if the water cement ration is common. For better pictorial representation, the variations in 7-14 days and 14-28 days are also symbolized in the kind of bar charts in the pattern 20. From the result, it is found that compressive strength increased with curing time. It found that the maximum intensity level was held with 10% RHA replaced with cement. It is let out from literature that cement in combination with 10% RHA contribute highest strength. Formation of calcium aluminosilicate hydrate is mainly responsible for the effectiveness and low swell of the treated RHA, as good as for heavy metal immobilization. The increased effectiveness is attributed to the increased amount of pozzolanic product formed due to increased amount of aluminum oxide and silica. [44] cement and cement silicate mixture are all effective in chemically stabilizing metal wastes. [45] high specific surface area of calcium silicate hydrate, aluminum, iron silicate, calcium aluminium oxide hydrates, entrapped heavy metal ions and stabilized them chemically. RHA improves the microstructure and durability of the hardened concrete. The physical force of the RHA particles increases the composites density and micro structural homogeneity by filling the micro pores, thereby densifying the structure which in turn gives an increase strength and decrease the porosity. [46].

V. Conclusion

The results of the study indicate that in that respect are good prospects of using RHA as pozzolana in combination with PPC in the structure industry. The RHA used in this study is a pozzolanic material; it is rich in silica (76.3%). The loss of ignition was relatively high (14.6%). Increasing RHA, fineness increases and increasing its responsiveness. An increment in the amount of RHA in the mix resulted in a dry and unworkable mixture unless SP is added. The inclusion of Sp in RHA concrete while maintaining the water cement ratio increased the slump and improved the cohesiveness of the concrete. The compressive strength of the blended concrete with 10% RHA obtained 39.11 N/mm^2 could be valuably replaced by RHA after 28 days curing. The compressive strength increases with curing time. The physical effect of the RHA particles increases the composites density and micro structural homogeneity by filling the micro pores, thereby densifying the structure which in turn yields increases strength and decrease the porosity. Hence RHA improves the microstructure and strength of the hardened concrete. From the study conducted, it was distinctly shown that RHA is a pozzolanic material that holds the potential to be applied as partial cement replacement material and can lead to the sustainability of the building stuff.

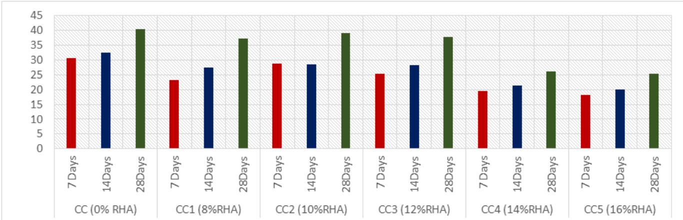

Figure No. 5 Compressive strength of RHA mix

Sample ID	Curing Time (Days)	Compressive Load	Area (sq.)mm	Compressive strength (N/mm2)
CC (0% RHA)	7 Days	69	22500	30.67
	14Days	72.9	22500	32.44
	28Days	90.99	22500	40.44
CC1 (8%RHA)	7 Days	52	22500	23.11
	14Days	61.49	22500	27.33
	28Days	83.99	22500	37.33
CC2 (10%RHA)	7 Days	58	22500	28.78
	14Days	63.99	22500	28.44
	28Days	87.99	22500	39.11
CC3 (12%RHA)	7 Days	56.99	22500	25.33
	14Day	63.49	22500	28.22

	s			
	28Days	85	22500	37.78
CC4 (14%RHA)	7 Days	44	22500	19.5
	14Days	47.99	22500	21.33
	28Days	58.99	22500	26.22
CC5 (16%RHA)	7 Days	40.9	22500	18.22
	14Days	45	22500	20
	28Days	56.9	22500	25.33

Table no.5 Compressive Strength of RHA mix

CRL	Percentage increase between 7-days to 14 days	Percentage increase between 14-days to 28 days
0%	57.71	24.66
8%	18.26	36.58
10%	10.32	37.52
12%	11.41	33.87
14%	9.05	22.93
16%	9.76	26.65

Table 7 - percentage increase in compressive strength of M35 grade rice husk ash concrete.

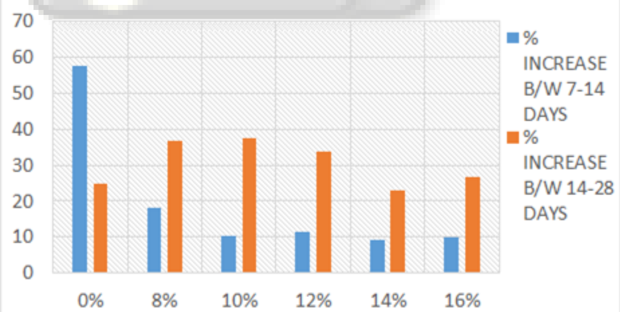

Fig no. 6 Increase in compressive strength of M35 grade Rice Husk Ash concrete

REFRENCES

[1] E.B. Ogunbode, I.O. HASSAN, R. B. Isa Department Of Building, Federal University of Technology, Minna, Niger State, Nigeria 88An evaluation of compressive strength of concrete made with Rice Husk Ash obtained by open air burning.

[2] M.B.G Sameer Kumar, D. Santosh Pushparaj, P.R.D Prasad ,K. Bipin Chandra Phan, G. Ramu A study of use of Rice husk ash in concrete Institute of Technology GitumUniversity25.

[3] Post graduate Student, Department of Civil Engineering, BIT Mesra, Ranchi-835215Study of the Properties of Concrete by Partial Replacement of Ordinary Portland Cement by Rice Husk Ash International Journal of Earth Sciences and Engineering ISSN 0974-5904, Volume 04, No 06 SPL, October 2011, pp. 965-968.

[4] Strength properties of grade 30 Rice Husk Ash concrete Kartini, K.*, Universiti Teknologi MARA, MalaysiaMahmud, H.B, University of Malaya, MalaysiaHamidah, M.S, Universiti Teknologi MARA, Malaysia31st Conference on our world in concrete: 16 - 17 August 2006, Singapore

[5] G. L. Oyekan*, University of Lagos, Lagos, Nigeria O. M. Kamiyo, University of Lagos, Lagos, Nigeria effect of Nigerian rice husk ash on some Engineering properties of concrete and sandcrete blocks 32ndConference on our worlds in concret structures: 28 - 29 August 2007,Singapore.

[6] J.Macsik and A. Jacobson, Original contribution-Leachability of U and Cr. From Ld- slag/ Portland cement stabilized sulphide soil, waste management, 16 (1996) P 699-709.

[7] P.Lawrence, M Cry,E. Ringot, Mineral admixtures in moratra of type, amount and fineness of fine constituents on compressive strength, cement concrete Res. 35 (2005) P 1092-105.

[8] V. Johansen, P.J.Andersen, particle packing and concrete properties. In : J Spacing, S. Mindess, editors, Materials science of concrete II. The American ceramic society inc;(1989) P 111-48.

[9] D.P.Bentz, influence of water cement ratio on hydration kinetics sinple models based on spatial consideration. Cement concrete Research,36(2006) P 238-44.

[10] M. Mazloom, A.A. Ramezaniapour, J.J. Brooks, Effect of sssssilica fume on mechanical properties of hifg- strength concrete,cement concrete comp 26,(2004) P 347-57

[11] M.Cry, P. Lawrence, E. Ringot, Efficiency of mineral admixture in mortars quantification of the physical and chemical effects of the fine admixtures in relation with compressive strength. Cement concrete research, 26 (2006)P 264-77.

[12] Technology Information, Forecasting and Assessment Council; Department of Science and Technology Government of India; http://www.tifac.org.in

