Effect of Alkaline Activator on Workability and Compressive Strength of Cement Concrete with RHA

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ABSTRACT:

Objectives of the investigations- To *study the suitability of the RHA as a pozzolanic material for replacement of cement in concrete. To improve the early strength (at ages 3,7, 14 days) of concrete with RHA by using alkaline activator.*
To make the concrete economical. To develop and satisfy various structural properties like compressive strength, Workability and Alkalinity To see the effect of alkaline activator on cement concrete with RHA. To obtain specific strength within specific time of cement concrete with RHA for particular situation (i.e. high performance strength concrete for sea shore structure, prestressing, blasting, nuclear power plant, bridge structures etc.). To find alternative binders to manufacture the concrete. To use low cost agricultural bi-product. To reduce environmental pollution.

Scope of the investigation- *To study the effect of alkaline activator NaOH and RHA on compressive strength, workability and alkalinity of cement concrete for :-Concrete grade – M30, Water to cementitious material ratio 0.5,Alkaline solution to cementitious material ratio – 0.35, Concrete mixes with RHA – 0%,10%,20% and 30%, NaOH concentration in morality M - 1,2,3 and 4, Mix design by – DOE method, Superplasticizer – Hydraproof - 1.5% of cementitious material , Workbility- By slump and compaction factor test, Compression test specimen – cube size 150*150* 15 mm, Curing method and age – 1) water curing – 3,7 and 14 days*

Keywords: *Rice husk ash(RHA),Molarity(M),Alkaline activator,sodium hydroxide(NaOH), compressive strength, Concrete grade 30,hydration,pazolanic reaction, pH value,slump,workability, calcium silicate hydrate (C-S-H gel),silica,plasticizer,*

I. INTRODUCTION:

Pozzolanic activity of RHA :-In hydration of cement major cement compounds like dicalcium silicates (C_2S), tricalcium silicates (C_3S), tricalcium aluminate (C_3A) and tetracalcium alumino ferrite (C_4AF) reacts with water, produces stable compound calcium silicate hydrate (C-S-H gel), calcium aluminates hydrate (C_3AH_6),calcium ferrite hydrate (C_3FH_6) and calcium hydroxide $Ca(OH)_2$ respectively. Hydration compounds consists of calcium hydroxide, which is not desirable product in the concrete mass. Calcium hydroxide is soluble in water and gets leached out making the concrete porous.

$2(3CaO\ SiO_3) + 6H_2O \rightarrow 3CaO.2SiO_2.3H_2O + 3Ca(OH)_2$
$2C_3S + 6H \rightarrow {}_3S_2H_3$ (C-S-H) gel $+ 3Ca(OH)_2$
wt. 100 24 5 49
OR
$2(2CaO.SiO_2) + 4H_2O \rightarrow 3CaO.2SiO_2.3H_2O + Ca(OH)_2$
$2C_2S + 4H \rightarrow C_3S_2H_3$ (C-S-H) gel $+ Ca(OH)_2$
100 21 99 22

RHA which is rich in silica exhibit pozzolanic activity. Reaction take place between the reactive silica present in RHA and calcium hydroxide formed during hydration of cement, produces stable compound calcium silicate hydrate (C-S-H gel.)

$SiO_2 + Ca(OH)_2 \rightarrow CaO.SiO_2.H_2O$ (C-S-H gel)

Alkaline activator and hydration processes:-

The laboratory grade sodium hydroxide in flake form with 97.8% purity was used as alkaline activator for the activation of RHA. It observed that the pozzolanic action of RHA with calcium hydroxide formed during the hydration of cement is very slow. Therefore compressive strength for larger replacement of cement (i.e. more than 20%) by RHA at shorter duration (upto 28 days) is less than that of conventional concrete. For large replacement more than 40% of cement by RHA the demand of water increases and reduces the rate of setting of concrete. Less quantity of cement in concrete with RHA, produces small amount of calcium hydroxide $Ca(OH)_2$ during the hydration process, which is insufficient for hydration with large amount of reactive silica presenting concrete due to large percentage of RHA to complete the reaction.

$SiO_2 + Ca(OH)_2 \rightarrow CaO.SiO_2.H_2O$ (C-S-H)

Therefore to activate the reaction of this excess reactive silica, activator in the form of Sodium Hydroxide (NaOH) is added in the concrete mix. The hydration process between the reactive silica (SiO_2) & Sodium Hydroxide (NaOH) produces stable compound sodium metasilicate and water

$SiO_2 + NaOH \rightarrow Na_2SiO_3 + H_2O$

Literature review : Literature is reviewed to learn about the results of previous studies that were related to this study.Need to find alternative binders to manufacture the concrete. RHA is a good super-pozzolanas , RHA much finer than cement particle size less than 45 micron, it fills the voids between cement and aggregate , Potential use of low cost rice husk ash. and gives the strength and density to the concrete. It can be reduce the amount of cement in the concrete mix. RHA reduces the thermal cracking High performance concrete with RHA It is an attempt made to replace the cement by part with RHA ,the agro waste product which is available in various parts of India in large amount. The rice husk ash used by various researchers was open burnt so the pozzolanic properties are not reserved.Here the used RHA is obtained From factory single source satisfied all the requirements of pozzolonic material as per I.S. The effect of higher percentage replacement, concentration of sodium hydroxide, fineness of source materials, type of activators, curing duration were not well investigated. These are the weak areas in which research work should be carried out. Therefore experimental work carried out in the project has been highlighted. From literature survey it is observed that the parameter suggested by different researchers and their results are not matching with each other ,may be due variation in properties of materials considered in the work.

System development:-Selection of various Parameters :-

Material properties:- RHA, F.A. ,C.A., Water, Cement & Super plasticizer ,RHA %, w/ b ratio, Curing method, temperature & age, Alkaline solution –to – cementitious material ratio by mass Alkaline activators Concentration of sodium hydroxide , Preparation of Sodium hydroxide solutuon:-

Molecular wt. of 40. 40gm NaOH / lit. =1M, Temp. rise 70^0c to 80^0c.

Fine Aggregate :- Locally available river sand is used .The sand is sieved by I.S. sieve of size 4.75 mm. Grading Zone 1 (IS 386-1970). properties of fine aggregates are tested as per IS 2386 (part 1,2 and 3) 1963 Method of tests for aggregate for concrete and confirming to IS 386-1970.

Coarse Aggregate :- Crushed angular basalt stone aggregate from a local source are used. 20mm and 10mm aggregates are used in 60:40 proportions Properties of coarse aggregates are tested as per IS 2386 (part 1,2 and 3) 1963 Method of tests for aggregate for concrete and confirming to IS 386-1970

Water :- Mixing water Potable tap water and distilled water

Cement :- Ultra-tech cement 53 grade OPC.Obtained from single source used.

Concrete mix design - Considerations : Design method used – D.O.E method.1988 British method. Concrete mix Design- for Characteristic strength 30 MPa . Crushed aggregates ,grading of fine aggregates 27% passes through 600 micron sieve , placing conditions requires a slump range 30-60 mm. concrete is to be used in mild exposure condition. Cover of reinforcement adopted 25 mm, specific gravity of fine aggregate 2.6 and coarse aggregate 2.66, proposed cement replacement by RHA 10%,20% and 30% by weight,

Batching, Mixing, Casting, curing and testing the specimens-

Concrete Batching method-Weight batching, Mixing procedure – IS:526-1959. Each batch of concrete immediately tested for workability by slumps as per IS:1199-1959, compaction factor . Mould used-150*150*150 mm size, oiling inner faces Compaction- by table vibrator and tamping rod, De-moulding period-24 Hrs. Curing method - Water curing - 3 days, 7days and 14 days,

Materials required for different mixes in kg /m^3

(RHA replacement 0%, 10%, 20% 30% for w/c ratio 0.63,0.58,0.54,and 0.50 respectively. (As per mix designs)

Sr. No.	Ingredients	Mix designations			
	Rice husk ash replacement	0%	10 %	20%	30%
1	W/c ratio	0.63	0.58	0.54	0.50
2	Cement	333.33	314.90	295.31	267.23
3	Rice husk ash	000.00	34.98	73.83	114.53
4	Cementitious material	333.33	349.88	369.14	381.76
5	F.A.	886.83	851,71	832.21	819.64
6	C.A.(60%) 20mm	572.30	591.18	599.19	612.35
7	C.A(40%). 10mm	381.54	393.13	399.46	408.23
8	Total C.A.	953.84	985.31	998.65	1020.58
9	Water	210	205	200	190
10	Super plasticizer dosel.5% of cementitious material 1.5% of cementitious material	5.0	5.25	5.54	5.73
11	(C+RHA) : F.A. :C.A. Proportion	1:2.66:2.86	1:2.43:2.81	1:2.25:2.70	1:2.14:2.67

Performance Analysis.

Parameter tested:-

i) Workability of RHA cement concrete with and without activator, ii) Compressive strength of RHA cement concrete with and without activator, iii) Alkalinity of cement concrete with, without RHA & NaOH, Observations and comparison between normal cement concrete mix , cement concrete with RHA, with and without alkaline activator NaOH.

1. Normal cement concrete (Cement concrete without RHA ,alkaline activator): (IDMark : CA0MO) Materials requirement, observations, & test results: (Table 1,2,3.)

Materials requirement for 9 cubes:

Table 1. Material requirement

Material	Required wt (kg)		Material	Required wt (kg)
Cement+RHA	11.65		NaOH Solution.	Nil.
Cement	11.65		Water in NaOH Solution	Nil.
RHA	Nil		NaOH Solid	Nil.
F.A.	30.99		Total Water	7.33
C.A. (20mm)	19.20		Free water	Nil
C.A. (10mm)	14.12		Plasticizer	Nil.
Total C.A.	33.32			

Observations and test results:

Table 2. Slump, weight, compactibility,compaction factor,pH,bleeding,segregation.		
Wt. of uncompacted Concrete (kg) :22.980	**Wt. of compacted Concrete (kg) : 23.420**	**Compaction factor : 0.98**
Slump (mm) : 180	**Compactibility :** Good	**Bleeding :** Nil
Segregation : Nil	**Finish of cube** : Good	**pH**=11.55

Table 3. Compressive Strength0f normal cement concrete in Mpa

Sr. No.	Curing Period in days	Wt. in Kg	Density (Kg/m^3)	Load KN	Comp Strength N/mm2	Avg. Comp. Strength N/mm^2	pH
1	3	8.770	2598.5	490	21.77	21.47	11.15
2	3	8.700	2577.7	480	21.33		
3	3	8.720	2583.7	480	21.33		
4	7	8.500	2518.5	650	28.88	27.84	11.14
5	7	8.660	2565.9	610	27.11		
6	7	8.600	2548.1	620	27.55		
7	14	8.705	2579.9	750	33.33	33.03	11.09
8	14	8.585	2543.7	740	32.88		
9	14	8.630	2557.0	740	32.88		

2. Cement concrete with RHA and Alkaline activator (NaOH)

Observations and results:

a) Slump: Table 4

Table 4 :Slump			
Conc. Of NaOH	Slump in mm for percentage cement replacement by RHA %		
in (M)	10%	20%	30%
0M	8	4	0
1M	8	5	1
2M	9	5	1
3M	10	6	2
4M	11	7	3

Figure 1. (Ref.Table 4)

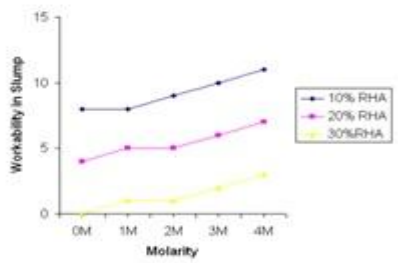


Table 5 :Compressive strength							
SR. NO.	RHA %	DAYS	Compressive Strength in MPa				
			Alkaline activator concentration in molarity (M)				
			0 M	1M	2M	3 M	4 M
1	0	3	24.33	-	-	-	-
	10		21.76	18.51	17.77	15.85	14.51
	20		18.66	23.18	12.29	11.55	11.99
	30		12.29	11.85	11.99	12.0	12.14
2	0	7	27.90	-	-	-	-
	10		27.84	23.66	22.81	19.10	16.29
	20		23.25	18.51	17.92	15.25	16.14
	30		13.62	14.66	15.10	15.20	15.40
3	0	14	33.00	-	-	-	-
	10		33.03	25.92	24.43	23.70	21.33
	20		33.92	25.18	24.14	17.03	19.40
	30		18.36	18.96	19.55	20.12	21.03

Figure 2 (Ref. Table 5) (RHA 10 %)

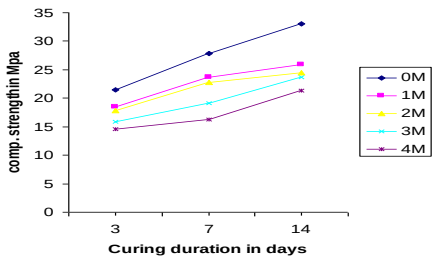


Figure 3 (Ref. Table 5) (RHA 20%)

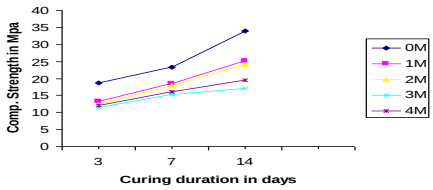


Figure 4 (Ref. Table 5) (30% RHA)

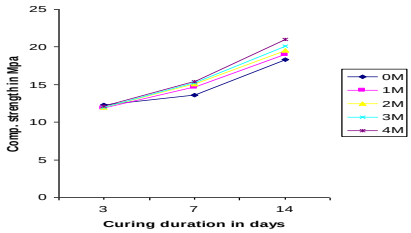
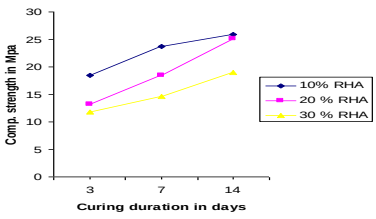
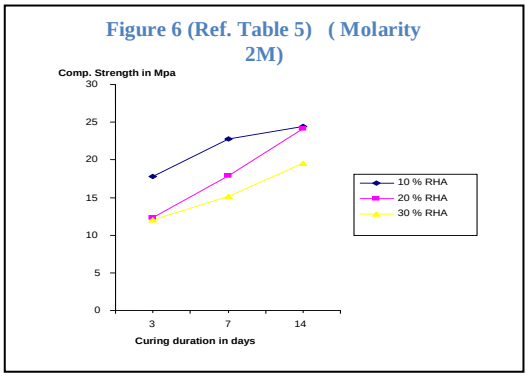
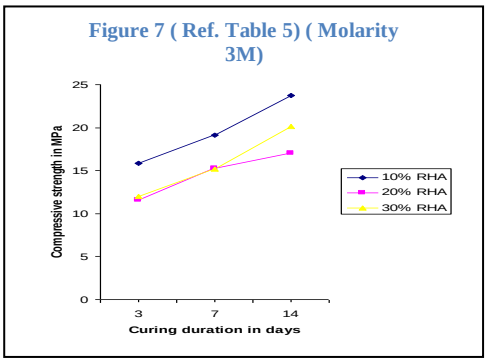
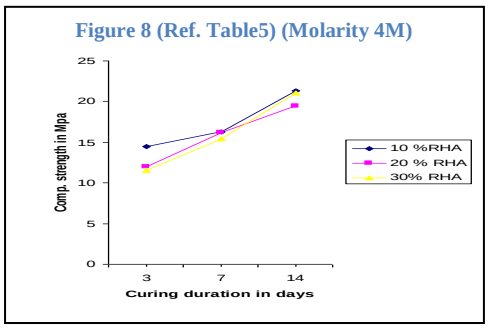


Figure 5 (Ref. table5) (Molarity 1M)









Discussion:

1) For 10 % RHA without NaOH comp. strength same as control mix with duration 7 &14 day. 2) At 14 days It is equal to reference concrete. reason may be due to RHA acts as a filler material or slow pozolanic reaction takes place with reactive silica.
3) For 10,20 % RHA,3,7,14 days comp. strength decreases with Increase in NaOH concentration, reason may be due to leaching or excess water.
4) But for 20 % RHA ,3 days comp. strength increases at 1M NaOH concentration, reason may be due to pozolanic reaction with reactive silica.
5) For 30 % RHA 3,7,14 days comp. Strength increases with increase in NaOH concentration and it is higher than reference concrete, reason may be due to pozolanic reaction takes place with reactive silica.

Conclusion: It shows even by replacing 30 % cement by Rice Husk Ash, required compressive strength can be achieved by using alkaline activator (NaoH). And thus Rice husk cement concrete of required grade for particular purpose may be prepared along with some performance test.

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