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Control of Conversion Reaction in High Alumina Cement by Adding Different Additives

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Abstract: ***This paper makes an attempt in experimental investigation for assessing the material characteristics and long-term performance of high alumina cement concrete construction at elevated temperature. High Alumina Cement (HAC), sometimes known as calcium aluminate cement (CAC) or aluminous cement) is composed of calcium aluminates, unlike Portland cement which is composed of calcium silicates. It is manufactured from limestone or chalk and bauxite. In unshaped refractories, High- alumina cements (HACs) are the main binder and are currently most used in industries. In the first generation of unshaped refractory, the HACs were the one and only binding agent used. High Alumina Cement (HAC) concrete is a high strength, sulphur resistance, fire resistant concrete used as a good refractory material. High strength in High Alumina Cement concrete is achievable under temperature control i.e, at low temperature (at 18±2^0 C) as per IS- 6452 and IS-4031. The use of HAC has its advantages in situations under low temperature for gain of early strength. However, HAC as a construction material has its inherent draw back due to its chemical conversion characteristics. HAC concrete when cured above 25^0 C results in loss of strength due to conversion reaction. The present investigation aims at studying the effect of mixing "conversion-preventing additive materials used in High alumina cement to control the exothermic reaction like Fly Ash, OPC, Crusher Dust, Rice Husk, Coconut Shell, Urea, Silica Zel, Tri-calcium Orthophosphate and Sodium Hexa-meta Phosphate etc. at 38^0 C of casting temperature to find the compressive strength of HAC for M_{40} grade concrete. The conversion reaction in high alumina cement/concrete samples is examined by X-Ray Diffraction. The setting time of high alumina cement (HAC) may be considerably influenced by addition of small quantities with gradually variation of 1%, 2%, 3% and 4% each of Fly Ash, OPC, Crusher Dust, Rice Husk, and Coconut Shell by weight of HAC in combined manner. The addition of above ingredients causes to decrease conversion reaction with water which has been studied. The use of temperatures more than 25°C during the hydration of high alumina cement in concrete leads to the formation of the cubic hydrate C_3AH_6. Hence, to avoid the conversion reaction in High Alumina Cement that results in formation of chemical compounds like CAH_{10} and C_3AH_6, different additives have been used to control the exothermic reaction inside the concrete mass. Concretes made with neat HAC have shown much reduced strength at 38°C after only three to four days, due to well known 'conversion' reactions. The hydration chemistry of blends of cement found and several mineral and chemical admixtures have been studied by using x-ray diffraction. The conclusion is that although the process is thermodynamically favoured by increasing temperatures of hydration, kinetically it is governed by the availability of free (liquid) water within the cement microstructure. High strength can be achieved in high alumina cement (HAC) through the incorporation of Fly Ash, OPC, Crusher Dust, Rice Husk and Coconut Shell additions.***

Keywords: Calcium Aluminate Cement, Fly Ash, OPC, Crusher Dust, Rice Husk, Coconut Shell, Urea, Silica Zel, Tri-calcium Orthophosphate (TCO), Sodium Hexa-meta Phosphate (SHMP), high temperature contents, low temperature contents, curing temperature, thermometers etc.

1. Introduction

The method of making cement from limestone and low-silica bauxite was patented in France in 1908 by Bied of the Pavin de Lafarge Company as a result of search for cement offering good sulphate resistance, high concrete strength and fire resistance to concrete. Later, it was used as a refractory material to resist high temperature, a functional requirement in industries. Once the high alumina cement concrete is hardened, it undergoes chemical change that results into reduction in the strength of concrete when cured in hot and humid environment conditions known as **Conversion**. During hydration process, the initially formed metastable hydrates of $\mathbf{CAH_{10}}$ **and** $\mathbf{C_2AH_8}$ are transformed to more stable hydrates of $\mathbf{C_3AH_6}$ with water and further give gibbsite as by-products. Under certain circumstances, the high alumina cement seriously affects its long-term durability as the cement becomes porous and losses its hydraulic strength and develops an increased vulnerability to corrosive attack. Thus, the use of high alumina cement for structural work has been regarded questionable due to conversion characteristic in High Alumina Cement but its best application is confined to use of concrete for rapid strength development under situations of low temperature,

2. References

Bradbury et al.[1] have studied the conversion reaction in high alumina cement/concrete samples by scanning electron microscopy and differential thermal analysis. The transformation which involves the dissolution of platy/acicular crystals of the metastable hydrates CAH1o and C2AH6 and the crystallisation of the lower hydrate C3AH6 (in the form of faceted icositetrahedra) is seen to be strongly influenced by the original water/cement ratio, both in facility with which it occurs and in the ultimate scale and distribution of the conversion products.

PiasZa J., Sawicz Z., Piasta W.G.[7] have studied the effect of additions of powdered limestone and quartz to HAC* pastes on sulphate resistance and rate of conversion in water. It is stated that the pastes with limestone addition are more resistant to sulphates and their degree of conversion is lowest in both environments.

Majumdar A J and Singh B.[4] have studied the compressive strength of concretes made from mixtures of 'Ciment Fondu' high-alumina cement and granulated blast furnace slag has shown an increasing trend up to 5 years when kept under water at 20 ° and 38°C. Concretes made from neat HAC have shown much reduced strength at 38°C after only one week, following the well known 'conversion' reactions.

Fu Yan, Ding Jian and Beaudoint J.J.[3] have studied the use of zeolites as conversion-preventing additives (CPA) for inhibition of hydro garnet formation in high alumina cement (HAC) products. Compressive strength development of HAC mortars containing the CPA additive is studied. The effect of curing conditions, from low initial temperatures to final high temperatures, on strength development was also investigated. X-ray diffraction (XRD) analysis was used to identify the hydration products in the HAC paste containing CPA.

Midgley H. G.[5] have studied the phase composition of high alumina cement clinkers may affect the strength development behaviour of concrete made from them and so a method of quantitatively determining these phases is needed. Quantitative X-ray diffraction using the adiabatic principle with auto flushing as proposed by Chung has proved to be a suitable method.

Beaudoln J. J.[2] have studied the properties of high alumina cement paste reinforced with mica flakes. The influence of small amounts of high aspect ratio mica flakes on the high alumina cement matrices is reported. Significant increases in flexural strength and fracture toughness were observed in mica-high alumina cement composites.

Perez M., Vazquez T. and Trivi6o F.[6] have studied the use of temperatures higher than 30°c during the hydration of (1:3) high alumina cement mortar leads to the formation of the cubic hydrated C3AH6, hence avoiding the conversion of CAH1o to C3AH6. The sub - sequent-carbonation of C3AH6 with C02 and thermal treatment leads to the formation of stable carbonated phases.

Redler LItszlb.[8] have studied the exact phase composition of high alumina cements, which was very important for both the cement production process and the development of new cement types. The most suitable method for its determination seemed to be the X-ray powder diffraction.

Taher M. A., Chandlert H. W. and Anderson9 A.[11] have studied the location and dispersion in the strength response of high alumina cement (SECAR 80) are explored in a series of factorial designs of experiments. The factors considered are water/cement ratio, cement/aggregate ratio with aggregate grade, the use of sodium hexa-meta-phosphate powder as a deflocculated during mixing, compacting pressure in the mould, curing time under water after setting and testing age.

Rayment D L and Majumdar A J.[9] have studied the typical chemical compositions of monocalcium aluminate (CA*), dicalcium silicate (C,S), the ferrite phase and of pleochroite present in HAC clinker by electron probe microanalysis.

Scian A.N., J.M., LSpez Porto and Pereira E.[10] have studied the influence of amorphization induced by milling in the hydraulic behaviour of commercial high alumina cement (CA25). The original starting cement and others with different degrees of treatment were characterized by XRD, Blaine and BET specific surface area, mean particle size and SEM.

3. Equations

The principal anhydrous constituent of HAC is monocalcium aluminates i.e, CA (CaO, Al_2O_3) and hydraulic compressive strength is dependent on the hydration products as per the following equation.

Hydration
CA -- CAH_{10} Conversion
C_2AH_8 + Alumina gel-----C_3AH_6 + Gibbsite (AH_3)

Conversion occurs due to initial hydration of CAH_{10} and C_2AH_8 which are metastable and transform continuously by time to be more stable hydrates C_3AH_6 with water and further gibbsite as by-products.

$3CAH_{10}$ _ $C_3AH_6 + 2AH_3 + 18H$ and
$3C_2AH_8$ _ $2C_3AH_6 + AH_3 + 9H$

Composition of High Alumina Cement:
The chemical analysis as supplied by the Lafarge Aluminous Cement Company Limited (Essex) is

Al_2O_3 : 73.5 %
CaO : 25.0 %
Fe_2O_3 : 0.40 %
SiO_2 : 0.20 %
Others : less than 1.0 %

Mix Design Calculation for **M_{40}** Grade Concrete by Using 100% HAC cement without using any foreign ingredients as per IS 10262:2009**:**

Name of the composition	Kg/M^3
HAC	493
Sand	615.574
20mm Aggregate	735.973
10mm Aggregate	490.649
Water	197.2
Dr. Fixit (Admixture)	1.972

Strength Analysis and Control the Exothermic reaction of High Alumina Cement concrete by replacing Fly Ash, OPC, Crusher Dust, Rise Husk, Coconut Shell up to 5% each and under a fixed proportion for each of Urea, Silica Zel, Tri-calcium Orthophosphate and Sodium Hexa-meta Phosphate

SL No	Name of Composition	Percentage of Composition by wt. of cement	Percentage of Composition by wt. of cement	Percentage of Composition by wt. of cement	Percentage of Composition by wt. of cement	Percentage of Composition by wt. of cement
1	HAC	100%	95%	90%	85%	80%
2	Fly Ash	-	1%	2%	3%	4%
3	OPC	-	1%	2%	3%	4%
4	Crusher Dust	-	1%	2%	3%	4%
5	Rise Husk	-	1%	2%	3%	4%
6	Coconut Shell	-	1%	2%	3%	4%
7	Sand	As per Mix Design Calculation				
8	20mm Aggregate					
9	10mm Aggregate					
10	Water	40%	40%			
11	Urea	-	0.5%			
12	Silica Zel	-	0.25%			
13	Tricalsium Orthophosphate	-	0.125%			
14	Sodium Hexameta Phosphate	-	0.062%			
15	Dr.Fixit (Water reducing Admixture) as per IS: 9103	0.4%	0.4%			

4. Experiment

Laboratory experimental investigation on compressive strength of high alumina cement with different ingredients at 38^0 C casting temperature for $\mathbf{M_{40}}$ Grade concrete has been conducted by taking same proportion of different additives. Conversion reaction in HAC may be controlled by adding different additive materials like Fly Ash, OPC, Crusher Dust, Rice Husk, and Coconut Shell combinedly in small quantities with gradually variation of 1%, 2%, 3% and 4% for each additive by weight of High Alumina Cement. By adding different proportions like, (i) 95% of HAC and rest 5% ingredients are (1% of fly ash, 1% of OPC, 1% of crusher dust, 1% of rice husk and 1% of coconut shell respectively. (ii) 90% of HAC and rest 10% ingredients are (2% of fly ash, 2% of OPC, 2% of crusher dust, 2% of rice husk and 2% of coconut shell respectively. (iii)85% of HAC and rest 15% ingredients are (3% of fly ash, 3% of OPC, 3% of crusher dust, 3% of rice husk and 3% of coconut shell respectively (iv) 80% of HAC and rest 20% ingredients are (4% of fly ash, 4% of OPC, 4% of crusher dust, 4% of rice husk and 4% of coconut shell respectively, cubes have been cast with fixed quantity of 0.5% of Urea, 0.25% of Silica gel, 0.125% of Tri-calcium Orthophosphate and 0.062% of Sodium Hexa-meta Phosphate added in all four mixes. The experiments were carried out on the basis of mix design considering 40% of water cement ratio and 0.4% of admixture. Concrete is cast into cubical size of (150mmX150mmX150mm) and curing start at 25^0 centigrade after 1 day. The compressive strength tests for each sample were carried out after 1 day, 3 days, 7 days, 14 days and 28 days of curing. One sample out of 3 samples were tested in X-Ray Diffraction machine and found the result as per Fig-1, 2, 3 and 4.

It was observed that the concrete behaviour was drastically changed after 10 to 30 minutes of mixing & the slump becomes Zero after 20minute. The maximum admixture dose of 0.4% used but the concrete is found workable up to 10 min of concrete mix. Hence it is highly essential to submit the compatibility test report of admixture with high alumina cement (Dr. Fixity-super plasticizer- water reducer type). For HAC concrete the desirable cube strength result should be approximately ~ 40MPa in 72 hours (3days) at site for M40 grade concrete.Compressive strength tests for each cement was carried out at an ambient temperature of 25℃ after 1 days, 3 days, 7days, 14 days, and 28 days of curing. After the curing period is over specimens were taken out from the curing chamber and excess water was wiped out from surface using dry jute or cotton cloths before placing in the compressive testing machine. It was observed that the maximum compressive strength was attained at mix sample-2. As per previous researches and concrete codes, the high alumina cement gives maximum compressive strength at curing environmental temperatures between16℃ to 20℃ without adding any foreign ingredients. In this study we used 493 kg of HAC cement with replaced HAC by 0%, 5%, 10%, 15%, and 20% by other ingredients in the mix design. For each mix 15 no's of cubes were prepared But here the casting temperature were maintained at 38^0 C and curing temperature maintained at 25^0 C. The compressive strength of cubes at 28 days found 15.84, 26.01, 48.01, 39.88 and 32.68 N/mm^2 respectively. The compressive strength rapidly decreases in the mix-1, with fewer increases in mix-3, 4, 5 and satisfying result found in mix-2. The exothermic reactions were controlled in all mix except mix-1 due to rapid exothermic reaction and heat evolved during setting of the concrete mix. The final values of compressive strength and graph were calculated as shown in Table-1 to 5 and graph-1 to 5.

Table 1: (HAC-100% and other ingredients-0%)

Sl No	HAC (kg)	Fly Ash (kg)	OPC (kg)	Crusher Dust (kg)	Rise Husk (kg)	Coconut Shell(kg)	Sand (kg)	20mm (kg)	10mm (kg)	water (lt)	Urea (kg)	Silica Zel(kg)	TCO (kg)	SHMP (kg)	Admixture (Dr. Fixit) (lt)
%	100%	-	-	-	-	-	Percentage with respect to HAC			40%	-	-	-	-	0.4%
1	493	-	-	-	-	-	750.75	813.45	542.3	197.2	-	-	-		1.172

Table 2: HAC-95% and other ingredients-5%

Sl No	HAC (kg)	Fly Ash (kg)	OPC (kg)	Crusher Dust (kg)	Rise Husk(kg)	Coconut Shell (kg)	Sand (kg)	20mm (kg)	10mm (kg)	water (lt)	Urea (kg)	Silica Zel (kg)	TCO (kg)	SHMP (kg)	Admixture (Dr. Fixit) (lt)
%	95%	1%	1%	1%	1%	1%	Percentage with respect to HAC			40%	0.5%	0.25%	0.125%	0.0625%	0.4%
1	468.35	4.93	4.93	4.93	4.93	4.93	750.75	813.45	542.3	197.2	1.972	0.986	0.493	0.2465	1.172

Table 3: HAC-90% and other ingredients-10%

Sl No	HAC (kg)	Fly Ash (kg)	OPC (kg)	Crusher Dust (kg)	Rise Husk (kg)	Coconut Shell (kg)	Sand (kg)	20mm (kg)	10mm (kg)	water (lt)	Urea (kg)	Silica Zel (kg)	TCO (kg)	SHMP (kg)	Admixture (Dr. Fixit) (lt)
%	90%	2%	2%	2%	2%	2%	Percentage with respect to HAC			40%	0.5%	0.25%	0.125%	0.0625%	0.4%
1	443.7	9.86	9.86	9.86	9.86	9.86	750.75	813.45	542.3	197.2	1.972	0.986	0.493	0.2465	1.172

Table 4: HAC-85% and other ingredients-15%

S No	HAC (kg)	Fly Ash (kg)	OPC (kg)	Crusher Dust (kg)	Rise Husk(kg)	Coconut Shell (kg)	Sand (kg)	20mm (kg)	10mm (kg)	water (lt)	Urea (kg)	Silica Zel (kg)	TCO (kg)	SHMP (kg)	Admixture (Dr. Fixit) (lt)
%	85%	3%	3%	3%	3%	3%	Percentage with respect to HAC			40%	0.5%	0.25%	0.125%	0.0625%	0.4%
1	419.05	14.79	14.79	14.79	14.79	14.79	750.75	813.45	542.3	197.2	1.972	0.986	0.493	0.2465	1.172

Table 5: HAC-80% and other ingredients-20%

Sl No	HAC (kg)	Fly Ash (kg)	OPC (kg)	Crusher Dust (kg)	Rise Husk (kg)	Coconut Shell(kg)	Sand (kg)	20mm (kg)	10mm (kg)	water (lt)	Urea (kg)	Silica Zel (kg)	TCO (kg)	SHMP (kg)	Admixture (Dr. Fixit) (lt)
%	80%	4%	4%	4%	4%	4%	Percentage with respect to HAC			40%	0.5%	0.25%	0.125%	0.0625%	0.4%
1	394.4	19.72	19.72	19.72	19.72	19.72	750.75	813.45	542.3	197.2	1.972	0.986	0.493	0.2465	1.172

Table I (Compressive Strength of HAC-100% and other ingredients-0%)

1st Day (N/mm^2)	3rd Day (N/mm^2)	7th Day (N/mm^2)	14th Day (N/mm^2)	28th Day (N/mm^2)
25.5	16.45	15.56	15.75	15.84

Table II (Compressive Strength of HAC-95% and other ingredients-5%)

1st Day (N/mm^2)	3rd Day (N/mm^2)	7th Day (N/mm^2)	14th Day (N/mm^2)	28th Day (N/mm^2)
28.76	27.62	26.85	26.04	26.01

Table III (Compressive Strength of HAC-90% and other ingredients-10%)

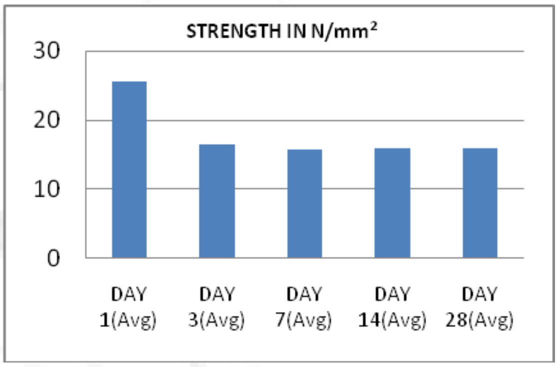
1st Day (N/mm^2)	3rd Day (N/mm^2)	7th Day (N/mm^2)	14th Day (N/mm^2)	28th Day (N/mm^2)
32.15	37.85	42.67	45.54	48.01

Table IV (Compressive Strength of HAC-85% and other ingredients-15%)

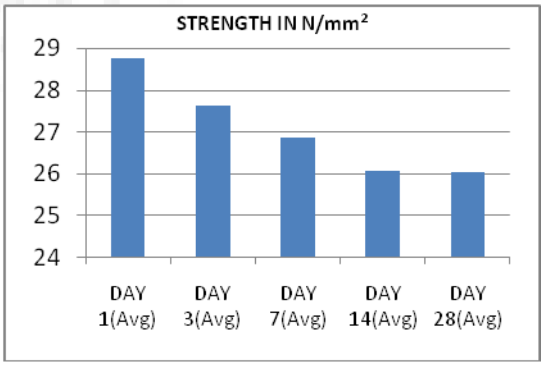
1st Day (N/mm^2)	3rd Day (N/mm^2)	7th Day (N/mm^2)	14th Day (N/mm^2)	28th Day (N/mm^2)
31.32	33.56	37.89	39.07	39.88

Table V (Compressive Strength of HAC-80% and other ingredients-20%)

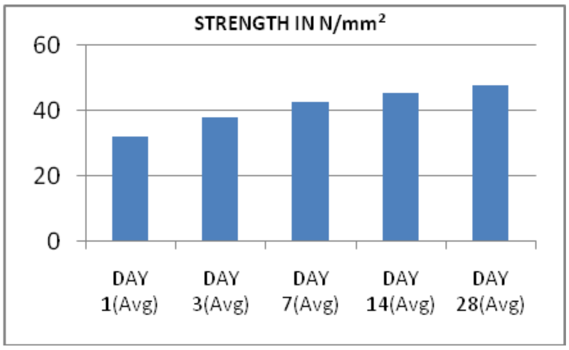
1st Day (N/mm^2)	3rd Day (N/mm^2)	7th Day (N/mm^2)	14th Day (N/mm^2)	28th Day (N/mm^2)
28.76	29.95	30.04	31.35	32.68



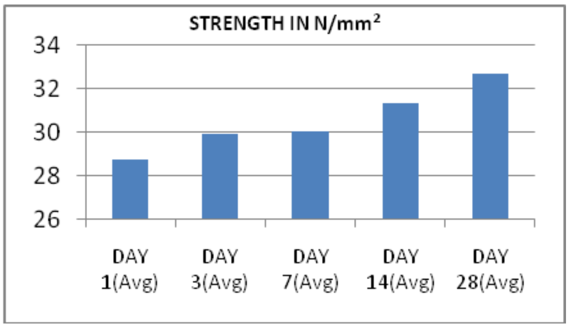
Graph-I (Compressive Strength of HAC-100% and other ingredients-0%)



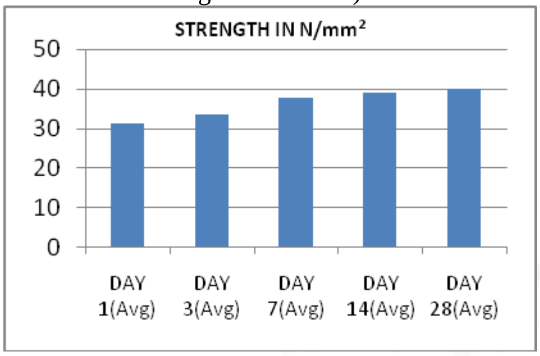
Graph -II (Compressive Strength of HAC-95% and other ingredients-5%)



Graph-III (Compressive Strength of HAC-90% and other ingredients-10%)



Graph –V: (Compressive Strength of HAC-80% and other ingredients-20%)



Graph -IV (Compressive Strength of HAC-85% and other ingredients-15%)

XRD Analysis of High Alumina Cement:

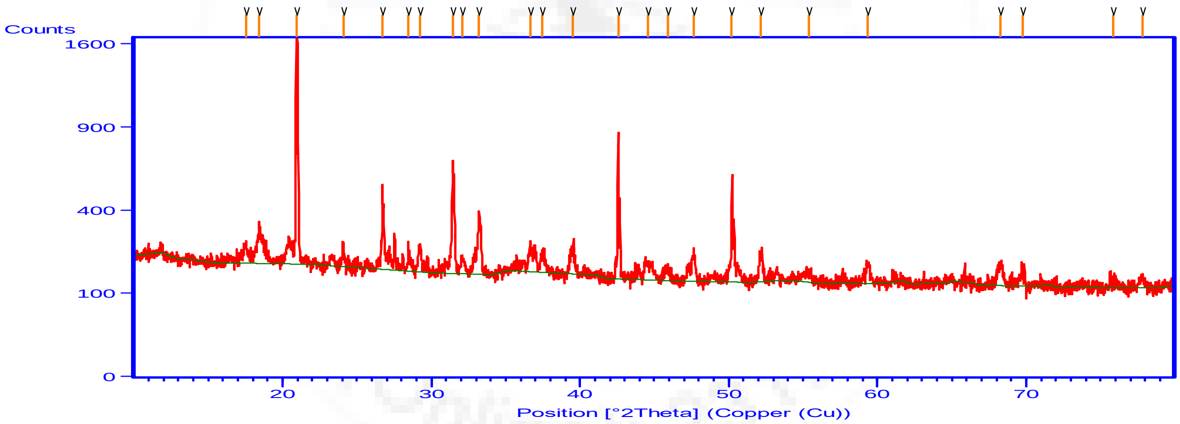


Figure 1: XRD analysis of Cement of (95% of HAC and rest 5% ingredients are (1% of fly ash, 1% of opc, 1% of crusher dust, 1% of rice husk and 1% of coconut shell respectively)

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
17.5285	66.07	0.2007	5.05966	5.44
18.4403	143.99	0.1338	4.81148	11.84
20.9638	1215.62	0.1004	4.23766	100.00
24.0913	87.85	0.1338	3.69415	7.23
26.7578	290.54	0.1004	3.33177	23.90
28.4764	89.44	0.1338	3.13448	7.36
29.2266	85.04	0.1673	3.05571	7.00
31.4576	516.11	0.1171	2.84390	42.46
32.1032	53.19	0.2676	2.78817	4.38
33.2335	231.18	0.2007	2.69588	19.02
36.6349	85.52	0.2007	2.45301	7.04
37.4792	64.76	0.2007	2.39967	5.33
39.5054	89.08	0.3346	2.28114	7.33
42.5529	465.76	0.1004	2.12456	38.31
44.5881	48.23	0.5353	2.03220	3.97
45.8717	31.40	0.4015	1.97828	2.58

47.6790	85.87	0.2342	1.90743	7.06
50.2106	353.67	0.1004	1.81703	29.09
52.1588	81.08	0.2676	1.75366	6.67
55.4238	25.61	0.5353	1.65784	2.11
59.3709	54.27	0.2676	1.55670	4.46
68.2441	58.29	0.4015	1.37432	4.80
69.7694	20.61	0.2676	1.34796	1.70
75.8046	18.53	0.4015	1.25495	1.52
77.7800	27.86	0.4015	1.22794	2.29

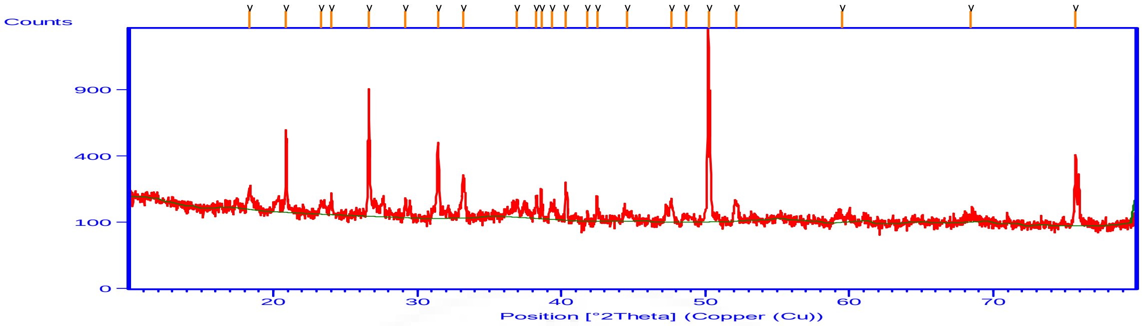


Figure 2:XRD analysis of Cement of (90% of HAC and rest 10% ingredients are (2% of fly ash, 2% of opc, 2% of crusher dust, 2% of rice husk and 2% of coconut shell respectively.)

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
18.3463	83.55	0.2676	4.83593	12.96
20.8759	440.96	0.1004	4.25531	68.40
23.3415	39.23	0.3346	3.81109	6.09
24.0406	67.23	0.1338	3.70184	10.43
26.6447	596.97	0.1004	3.34566	92.60
29.1542	76.64	0.1171	3.06313	11.89
31.4338	370.17	0.1171	2.84600	57.42
33.2077	170.53	0.1673	2.69792	26.45
36.9009	37.48	0.8029	2.43594	5.81
38.2777	82.65	0.1004	2.35143	12.82
38.6188	95.18	0.1004	2.33144	14.76
39.3252	50.10	0.2676	2.29118	7.77
40.3313	103.19	0.1673	2.23631	16.01
41.8320	26.03	0.2007	2.15949	4.04
42.4743	72.63	0.1004	2.12831	11.27
44.5402	29.17	0.5353	2.03428	4.53
47.6251	75.43	0.1673	1.90946	11.70
48.6716	17.24	0.6691	1.87083	2.67
50.2474	644.64	0.2007	1.81579	100.00
52.1101	67.80	0.2676	1.75518	10.52
59.5259	16.22	0.8029	1.55302	2.52
68.4115	19.48	0.8029	1.37137	3.02
75.6976	317.87	0.1338	1.25646	49.31

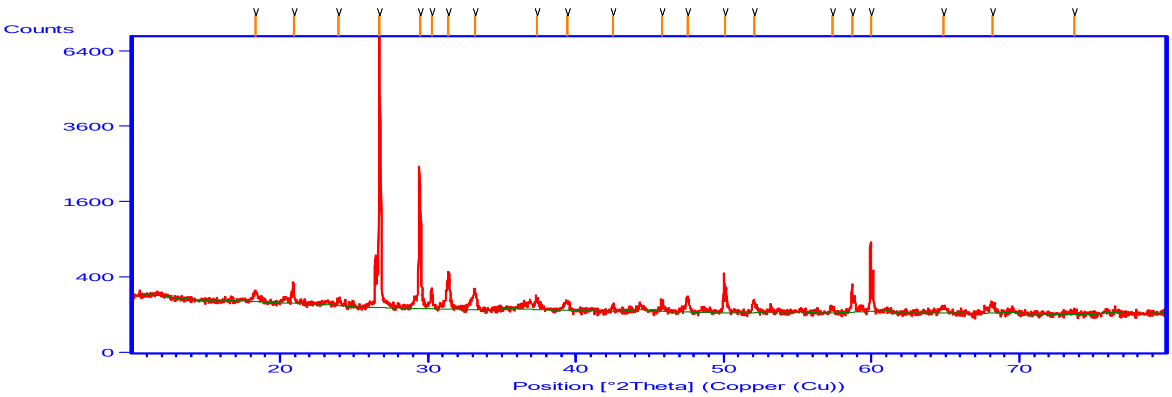


Figure 3: XRD analysis of Cement of (85% of HAC and rest 15% ingredients are (3% of fly ash, 3% of opc, 3% of crusher dust, 3% of rice husk and 3% of coconut shell respectively.)

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
18.3352	79.47	0.2007	4.83883	1.61
20.9157	154.97	0.1338	4.24731	3.13
23.9909	44.68	0.2007	3.70939	0.90
26.7561	4947.84	0.1004	3.33198	100.00
29.4501	1991.97	0.1338	3.03302	40.26
30.2687	125.54	0.1004	2.95284	2.54
31.3939	336.39	0.1171	2.84953	6.80
33.1599	165.06	0.1673	2.70169	3.34
37.3755	65.53	0.2676	2.40609	1.32
39.4336	58.16	0.2676	2.28513	1.18
42.5301	37.94	0.2007	2.12565	0.77
45.7914	79.24	0.1338	1.98156	1.60
47.5720	98.99	0.1673	1.91147	2.00
50.0809	186.24	0.2007	1.82144	3.76
52.0461	69.55	0.2007	1.75719	1.41
57.3212	24.84	0.2007	1.60739	0.50
58.6776	199.91	0.1004	1.57343	4.04
59.9878	296.43	0.2007	1.54216	5.99
64.8627	38.04	0.4015	1.43754	0.77
68.2053	42.24	0.2676	1.37501	0.85
73.7385	16.14	0.5353	1.28491	0.33

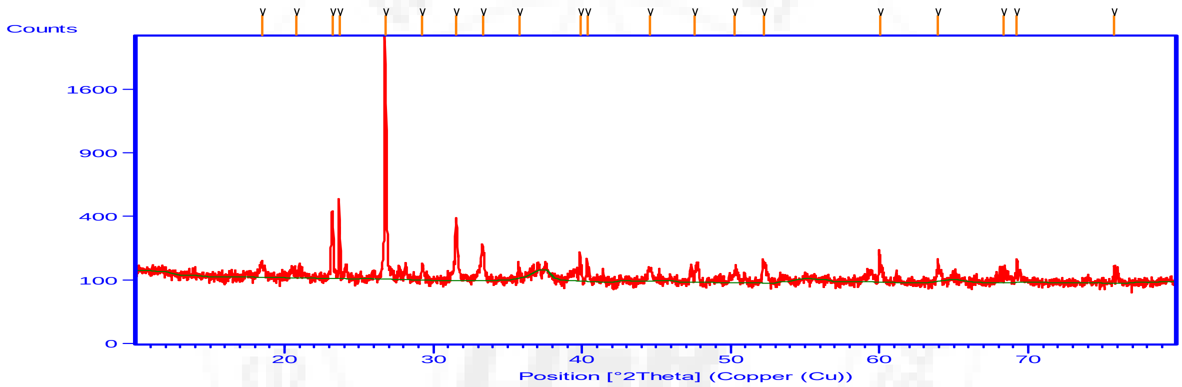


Figure 4: XRD analysis of Cement of (80% of HAC and rest 20% ingredients are (4% of fly ash, 4% of opc, 4% of crusher dust, 4% of rice husk and 4% of coconut shell respectively.)

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
18.4745	53.24	0.2007	4.80266	2.73
20.8198	20.79	0.8029	4.26664	1.06
23.2085	331.34	0.1171	3.83263	16.97
23.6927	323.87	0.1004	3.75540	16.58
26.7822	1953.01	0.1004	3.32880	100.00
29.2810	54.42	0.1004	3.05016	2.79
31.5381	281.82	0.1004	2.83683	14.43
33.3186	129.66	0.1338	2.68919	6.64
35.7759	33.34	0.2007	2.50992	1.71
39.9077	57.57	0.2007	2.25907	2.95
40.3808	38.44	0.2007	2.23369	1.97
44.5695	38.88	0.2007	2.03301	1.99
47.5965	31.53	0.6691	1.91054	1.61
50.2640	33.49	0.4015	1.81523	1.72
52.2303	65.71	0.2676	1.75143	3.36
60.0463	62.18	0.2007	1.54080	3.18
63.9274	73.14	0.1004	1.45630	3.75
68.3687	35.79	0.5353	1.37212	1.83
69.2421	59.27	0.2007	1.35693	3.03
75.7838	62.59	0.1224	1.25420	3.21

5. Result and Discussion

High early strength may be obtained by HAC cement at low ambient temperature. The usual strength of HAC is much affected by the hydration due to exothermic reaction as conventional casting temperature is more than 200 C in tropical climate since CAH10 and C2AH8 are the dominant hydration products. The strength of HAC concrete initially under this condition may drop significantly due to conversion of CAH10 and C2AH8 to C3AH6, when the ambient temperature increases. This conversion due to exothermic reaction in the fresh concrete mass may be controlled by using different ingredients like Fly Ash, OPC, Crusher Dust, Rice Husk and Coconut Shell. The degree of strength of HAC concrete were very less when only HAC cement was used in the mix without adding any ingredient, as conversion reaction in the concrete mass at mixing temperature was 380 C and curing temperature was at 250C. But when Fly Ash, OPC, Crusher Dust, Rice Husk and Coconut Shell ingredients were added at different percentages, it is found that maximum 28 days strength is attainable at 2% mix and in other mix, the strength is not achieved as per mix design but the conversion reaction is controlled as per the cube test results and from XRD test reports.

6. Conclusions

It is concluded that the additive materials like Fly Ash, OPC, Crusher Dust, Rice Husk, and Coconut Shell combined in small quantities in appropriate proportions can enhance comprehensive strength of High Alumina Cement Concrete offsetting the normal conversion reaction. However, to establish the mechanism that plays in increasing the strength of High Alumina Cement by controlling the conversion reaction in presence of additive materials, further experimental investigations are required.

References

[1] Cement/concrete", Materials Science and Engineering, Vol-23, pp. 43- 53.

[2] Beaudoln J. J.,(1982), '2' "Properties of high alumina cement paste reinforced with mica flakes" Cement and Concrete research. vol. 12, pp. 157-166.

[3] Fu Yan, Ding Jian, and Beaudoint J.J., '3' (1996), "Zeolite-Based Additives for High Alumina Cement Products" Cement and Concrete research, Vol.-3, pp. 37-42.

[4] Majumdar A J and Singh B, '4' (1992), "Properties of some blended high-alumina cements" Cement and Concrete research. vol. 22, pp. 1101-1114.

[5] Midgley H. G., '5' (1976), "Quantitative determination of phases in high alumina cement clinkers by x-ray diffraction" Cement and Concrete research. vol- 6, pp. 217-224.

[6] Perez M., Vazquez T. and Trivi6o F., '6' (1983) "Study of stabilized phases in high alumina cement mortars part i" Cement and Concrete research. vol. 13, pp. 759-770.

[7] PiasZa J., Sawicz Z., Piasta W.G., '7' (1988), "Durability of high alumina cement pastes with mineral additions in water sulfate environment" Cement and Concrete research. vol. 19, pp. i03-113.

[8] Redler LItszlb, '8' (1991) "Quantitative x-ray diffraction analysis of high alumina cements" Cement and Concrete research. Vol. 21, pp. 873-884.

[9] Rayment D L and Majumdar A J, '9' (1994) "Microanalysis of high-alumina cement clinker and hydrated hac/slag mixtures" Cement and Concrete research, vol. 24, no. 2, pp. 335-342.

[10] Scian A.N., J.M., LSpez Porto and Pereira E., '10' (1991) "Mechanochemical activation of high alumina cements - hydration behaviour-i. Cement and Concrete research. vol. 21, pp. 51-60.

[11] Taher M. A., Chandlert H. W. and Anderson9 A., '11' (1996), "Factors influencing consistency of strength of high alumina cement" Construction and Building Materials, Vol. 10, No. 7, pp. 491-500.

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