

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 10, October 2018

Experimental Investigation of High Alumina Cement Concrete with Additives

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ABSTRACT: The use of aluminate cements in construction materials is problematic (and sometimes even banned) because of conversion of aluminates, taking place slowly in time. The effect of such conversion is the increase of porosity, failure of interlocking between concrete ingredients leading to reduction of strength. Using many additive materials like zeolites, calcium phosphate, pleochroite, mica flakes, water glass, fibres, fly Ash, OPC, crusher Dust, rice husk, coconut shell, urea, silica zel, tri-calcium orthophosphate and Sodium Hexa-meta Phosphate etc. in High alumina cement (HAC) can control or significantly slower or offset the exothermic reaction inherent in it. This paper outlines experimental investigation of mixing “different conversion-preventing additive materials in High alumina cement to control the exothermic reaction during the setting period where casting and curing temperature are at 38⁰C and 25⁰C respectively to find the compressive strength of HAC for M₄₀ grade of concrete. This research work is carried out in order to explore the effect of various replacement percentages of high alumina cement with individual and combined additives to find the design compressive strength and to assess control of the exothermic reaction. The conversion reaction in high alumina cement/concrete samples is examined by X-Ray Diffraction.

KEYWORDS: Fly-ash, OPC, Crusher Dust, Rice Husk, Coconut Shell, Marble Dust, Water, Urea, Silica Zel, Tri-Calcium Orthophosphate (TCO), Sodium Hexa-meta Phosphate (SHMP), High Temperature Contents, Low Temperature Contents, Curing Temperature, Thermometers etc.

I. INTRODUCTION

High Alumina Cement (HAC) differs from Ordinary Portland Cement (OPC) in its important constituents being calcium aluminates rather than calcium silicates. HAC is also known as Calcium Aluminate Cement (CAC). Its rapid strength development property makes HAC popular since 1950 to till date. However, mineralogical conversion sometimes causes reduction in strength and increased vulnerability to chemical attack. Compressive strength and durability of concrete are mainly dependent on many factors like quality of raw ingredients, type of admixtures, curing temperature and field condition etc.

High Alumina Cement is an inorganic material that forms a dense texture when it reacts with water and has an excellent quick hardening refractory property and resistant to chemical attacks. This cement is very suitable for undersea applications and sewer concrete pipe lines. It can be used in cold region area where rapid strength development is required. HAC is also used in refractory concretes where it requires more strength at very high temperature. It acts as a good bonding material when added in refractory castables because it forms ceramic bond at high temperatures and thus has high resistance to chemical corrosion. So, it is widely used also in construction of water pipes, factory drains, factory chimneys and in costal constructions. It sets quickly and attains higher ultimate strength in a short period. Its strength is about 40N/mm² after 1 day and about 50 N/mm² after 3 days. Its setting action mainly depends on the chemical reactions and hence it is not necessary to grind it to fine powder. However, it cannot be used in mass construction work as it evolves huge amount of heat through its fast setting reaction. It is costly and losses relative strength in humid environment and high temperature.

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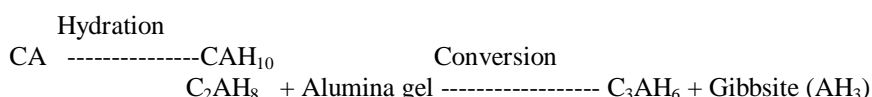
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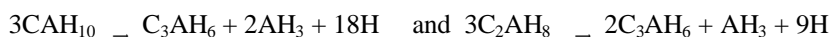
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High strength in High Alumina Cement concrete is achievable under temperature control i.e, at low temperature (at $18\pm 20^{\circ}\text{C}$) as per IS- 6452 and IS-4031. The use of HAC has its advantages in situations under low temperature for gain of early and optimum strength. However, HAC as a unique construction material in different construction field has its inherent draw back due to its chemical conversion characteristics. 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. HAC concrete when cured above 25°C results in loss of strength due to conversion reaction. The present investigation aims to experiment the effect of mixing "different conversion-preventing additive materials in High alumina cement to control the exothermic reaction during the setting period at 38°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 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.

II. CHEMICAL ANALYSIS



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.



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 %

III. THE EXPERIMENTAL MODELS

The present investigation aims at studying effect of mixing of fly-ash, OPC, crusher dust, rice husk, coconut shell and marble dust with varying proportions and taking water, urea, silica zel, tri-calcium orthophosphate and sodium Hexa-meta phosphate in fixed proportion with High Alumina Cement at 38°C of casting temperature and 25°C of curing temperature to find the compressive strength of HAC for M_{40} grade concrete. The conversion reaction in high alumina cement/concrete samples are examined by adding different additives with fixed proportion to control the exothermic reaction inside the concrete mass after being cast at site and checked by X-Ray Diffraction in the laboratory. It is found that the setting time of high alumina cement (HAC) may be considerably influenced by addition of minimum and optimum quantities of fly-ash, OPC, crusher dust, rice husk, coconut shell and marble dust ranging from 2.5% to 12.5% at an increment of 2.5% each and under a fixed proportion of water, urea, silica zel, tri-calcium orthophosphate and sodium hexa-meta phosphate in each case.

The Mix Design Calculation as per IS 10262:2009 for M_{40} Grade of Concrete by Using 100% of HAC cement without using any foreign ingredients is given in table-I:

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Table No-I

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

The individual additives selected for the purpose of studying influence on strength and conversion characteristics of high alumina cement are fly-ash, OPC, crusher dust, rice husk, coconut shell and marble dust. In each additive case, the replacements are done with gradual variation at 2.5%, 5.0%, 7.5%, 10.0% and 12.5% by weight of alumina cement. In each case, the varied percentage of different additives are mixed with fixed proportion of water, urea, silica zel, tri-calcium orthophosphate, sodium hexa-meta phosphate and admixture at 40%, 0.0625%, 0.125%, 0.25%, 0.5% , 0.4% respectively measured by weight of alumina cement. 15 cm x 15 cm x 15 cm cubes have been prepared in the laboratory with different proportion of individual and fixed additives and cured for 28 days in controlled temperature at 25⁰ C. The controlled temperature is maintained by surrounding ice block. The cube compressive strengths are obtained after 1 day, 3 day, 7 days and 28 days. The X-ray diffractions have been conducted for broken samples under different ages with following standard procedure.

The strength and control of the exothermic reaction of High Alumina Cement concrete are studied by replacing additives like fly-ash, OPC, crusher dust, rice husk, coconut shell and marble dust with gradual variation at 2.5%, 5.0%, 7.5%, 10.0% and 12.5% by weight of alumina cement under as follows shown from table number 1 to 31:

Sl No	HAC	Fly Ash	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	100%	-	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	5.0	-	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.1- (HAC-100%)

Sl No	HAC	Fly Ash	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	97.5%	2.50%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.875	0.125	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.2- (HAC-97.5% and Flyash-2.5%)

Sl No	HAC	OPC	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	97.5%	2.50%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.875	0.125	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.3- (HAC-97.5% and OPC-2.5%)

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Sl No	HAC	Crusher Dust	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	97.5%	2.50%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.875	0.125	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.4- (HAC-97.5% and Crusher Dust-2.5%)

Sl No	HAC	Rice Husk	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	97.5%	2.50%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.875	0.125	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.5- (HAC-97.5% and Rice Husk-2.5%)

Sl No	HAC	Coconut Shell	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	97.5%	2.50%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.875	0.125	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.6- (HAC-97.5% and Coconut Shell-2.5%)

Sl No	HAC	Marble Dust	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	97.5%	2.50%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.875	0.125	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.7- (HAC-97.5% and Marble Dust-2.5%)

Sl No	HAC	Fly Ash	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	95%	5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.75	0.25	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.8- (HAC-95% and Flyash-5%)

Sl No	HAC	OPC	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	95%	5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.75	0.25	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.9- (HAC-95% and OPC-5%)

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Sl No	HAC	Crusher Dust	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	95%	5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.75	0.25	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.10- (HAC-95% and Crusher Dust-5%)

Sl No	HAC	Rice Husk	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	95%	5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.75	0.25	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.11- (HAC-95% and Rice Husk-5%)

Sl No	HAC	Coconut Shell	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	95%	5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.75	0.25	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.12- (HAC-95% and Coconut Shell-5%)

Sl No	HAC	Marble Dust	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	95%	5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.75	0.25	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.13- (HAC-95% and Marble Dust-5%)

Sl No	HAC	Fly Ash	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	92.5%	7.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.625	0.375	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.14- (HAC-92.5% and Flyash-7.5%)

Sl No	HAC	OPC	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	92.5%	7.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.625	0.375	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.15- (HAC-92.5% and OPC-7.5%)

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Sl No	HAC	Crusher Dust	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	92.5%	7.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.625	0.375	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.16- (HAC-92.5% and Crusher Dust-7.5%)

Sl No	HAC	Rice Husk	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	92.5%	7.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.625	0.375	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.17- (HAC-92.5% and Rice Husk-7.5%)

Sl No	HAC	Coconut Shell	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	92.5%	7.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.625	0.375	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.18- (HAC-92.5% and Coconut Shell-7.5%)

Sl No	HAC	Marble Dust	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	92.5%	7.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.625	0.375	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.19- (HAC-92.5% and Marble Dust-7.5%)

Sl No	HAC	Fly Ash	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	90%	10%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.50	0.50	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.20- (HAC-90% and Flyash-10%)

Sl No	HAC	OPC	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	90%	10%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.50	0.50	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.21- (HAC-90% and OPC-10%)

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Sl No	HAC	Crusher Dust	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	90%	10%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.50	0.50	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.22- (HAC-90% and Crusher Dust-10%)

Sl No	HAC	Rice Husk	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	90%	10%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.50	0.50	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.23- (HAC-90% and Rice Husk-10%)

Sl No	HAC	Coconut Shell	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	90%	10%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.50	0.50	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.24- (HAC-90% and Coconut Shell-10%)

Sl No	HAC	Marble Dust	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	90%	10%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.50	0.50	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.25- (HAC-90% and Marble Dust-10%)

Sl No	HAC	Fly Ash	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	87.5%	12.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.375	0.625	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.26- (HAC-87.50% and Flyash-12.50%)

Sl No	HAC	OPC	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	87.5%	12.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.375	0.625	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.27- (HAC-87.50% and OPC-12.50%)

Sl No	HAC	Crusher Dust	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	87.5%	12.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.375	0.625	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.28- (HAC-87.50% and Crusher Dust-12.50%)

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Sl No	HAC	Rice Husk	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	87.5%	12.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.375	0.625	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.29- (HAC-87.50% and Rice Husk-12.50%)

Sl No	HAC	Coconut Shell	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	87.5%	12.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.375	0.625	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.30- (HAC-87.50% and Coconut Shell-12.50%)

Sl No	HAC	Marble Dust	Sand	20mm	10mm	water	Urea	Silica zel	TCO	SHMP	Admix
	(kg)	(kg)	(kg)	(kg)	(kg)	(lt)	(gm)	(gm)	(gm)	(gm)	(ml)
%	87.5%	12.5%	As per mix design			40 %	0.0625 %	0.125%	0.25%	0.5%	0.4%
Qty	4.375	0.625	7.614	8.25	5.50	2.0	3.125	6.25	12.50	25.0	20.0

Table No.31- (HAC-87.50% and Marble Dust-12.50%)

IV. XRD ANALYSIS OF HIGH ALUMINA CEMENT

Typical XRD analysis for samples with HAC and additive replacements are shown in figures 1 to 7 with replacement as 0 and 5% of different additives.

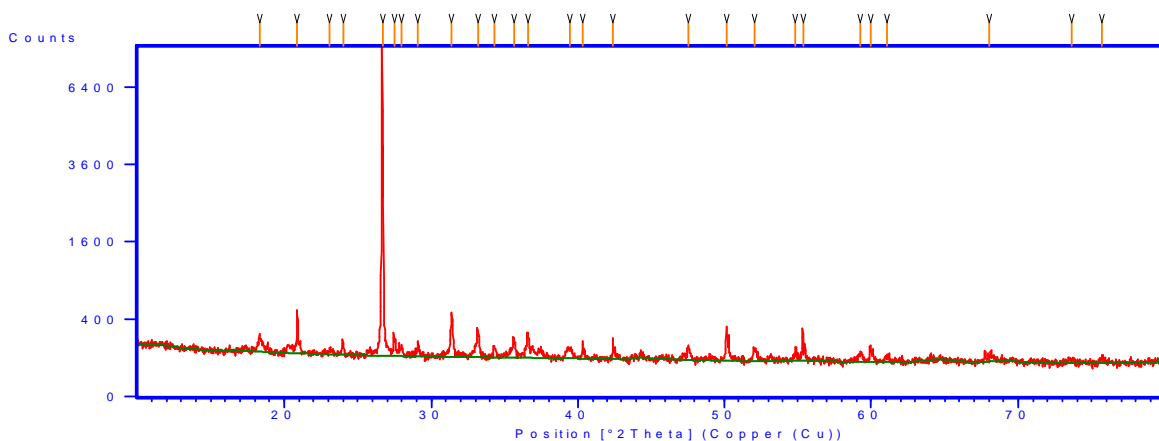


Fig-1: XRD analysis of Cement of (100% of HAC)

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Pos. [$^{\circ}2\theta$.]	Height [cts]	FWHM Left [$^{\circ}2\theta$.]	d-spacing [\AA]	Rel. Int. [%]
18.3371	91.31	0.2676	4.83833	1.95
20.8966	367.60	0.1004	4.25114	7.87
23.1141	23.19	0.4015	3.84808	0.50
24.0010	73.39	0.1004	3.70785	1.57
26.6898	4672.21	0.1004	3.34011	100.00
27.4954	116.40	0.1004	3.24405	2.49
27.9538	47.60	0.2007	3.19188	1.02
29.1135	85.17	0.1338	3.06732	1.82
31.3793	369.20	0.1004	2.85082	7.90
33.1715	175.99	0.1673	2.70078	3.77
34.2773	68.88	0.1673	2.61614	1.47
35.6134	116.21	0.1673	2.52099	2.49
36.5732	165.94	0.1338	2.45701	3.55
39.4279	52.21	0.4015	2.28545	1.12
40.3304	59.41	0.2007	2.23636	1.27
42.4360	88.95	0.1004	2.13015	1.90
47.5563	70.56	0.1673	1.91206	1.51
50.1555	231.99	0.1004	1.81890	4.97
52.0855	62.19	0.2007	1.75596	1.33
54.8533	46.72	0.2007	1.67372	1.00
55.3824	102.66	0.1338	1.65898	2.20
59.2524	39.45	0.2007	1.55953	0.84
59.9388	92.43	0.1004	1.54330	1.98
61.0750	24.32	0.4015	1.51729	0.52
67.9847	20.15	0.5353	1.37893	0.43
73.6103	16.08	0.8029	1.28683	0.34
75.6981	22.20	0.4015	1.25645	0.48

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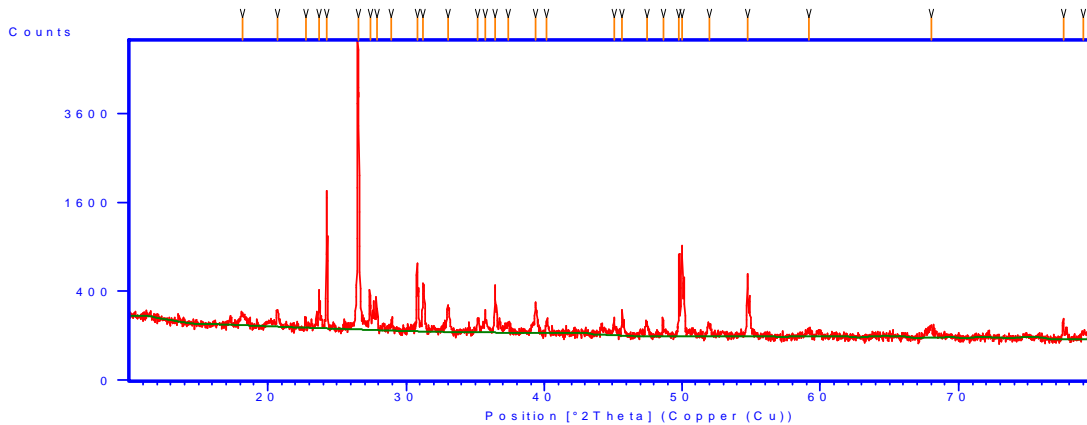


Fig-2: XRD analysis of Cement of (95% of HAC and rest 5% is Fly ash)

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
18.1833	70.44	0.3346	4.87890	1.39
20.6961	100.44	0.1004	4.29188	1.98
22.7531	56.50	0.1004	3.90830	1.11
23.7345	178.52	0.1004	3.74888	3.52
24.2835	1106.98	0.1004	3.66536	21.82
26.5473	5073.25	0.1004	3.35771	100.00
27.3925	193.41	0.2007	3.25599	3.81
27.8828	122.18	0.1004	3.19984	2.41
28.9484	37.53	0.4015	3.08444	0.74
30.8210	423.31	0.1338	2.90117	8.34
31.2570	351.39	0.1004	2.86169	6.93
33.0482	138.35	0.1673	2.71057	2.73
35.2035	59.74	0.1338	2.54940	1.18
35.7411	89.53	0.1004	2.51228	1.76
36.4544	248.43	0.1004	2.46475	4.90
37.3693	42.55	0.4015	2.40648	0.84
39.3697	167.85	0.1338	2.28869	3.31
40.1682	61.23	0.1338	2.24502	1.21
45.1067	82.22	0.1004	2.01004	1.62
45.6819	112.07	0.1004	1.98606	2.21
47.4499	62.19	0.2007	1.91610	1.23
48.6481	76.79	0.1004	1.87167	1.51
49.7999	511.27	0.1224	1.82954	10.08
50.0228	812.18	0.1171	1.82341	16.01
51.9726	56.54	0.2676	1.75950	1.11
54.7346	391.70	0.1004	1.67707	7.72
59.2085	33.87	0.2676	1.56058	0.67
67.9983	45.47	0.5353	1.37869	0.90
77.5522	98.26	0.1224	1.22996	1.94
79.0168	29.30	0.3346	1.21180	0.58

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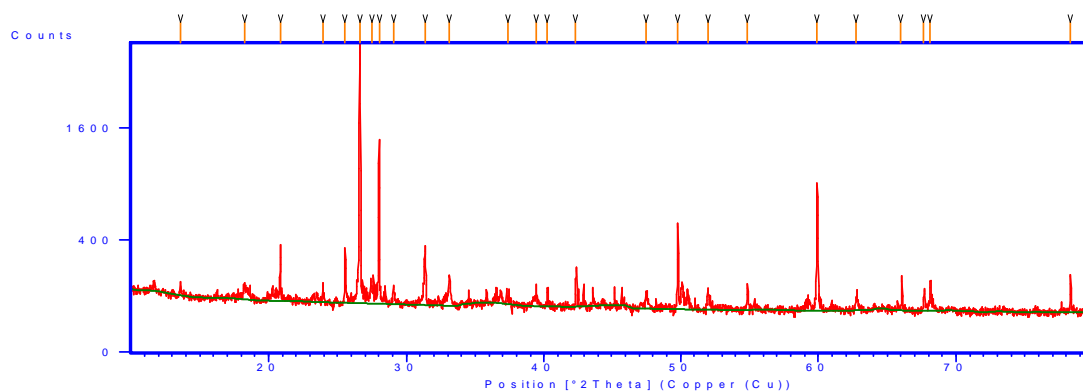


Fig-3: XRD analysis of Cement of (95% of HAC and rest 5% is OPC)

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
13.6024	25.60	0.2007	6.50456	1.29
18.2679	49.15	0.2676	4.85250	2.47
20.8663	156.82	0.1004	4.25373	7.89
23.9597	37.14	0.1338	3.71107	1.87
25.5616	167.85	0.1338	3.48202	8.44
26.6345	1988.66	0.1004	3.34414	100.00
27.4962	61.80	0.2676	3.24127	3.11
28.0257	526.97	0.1004	3.18122	26.50
29.0825	44.29	0.1338	3.06798	2.23
31.3595	199.60	0.1338	2.85021	10.04
33.1136	96.14	0.1338	2.70313	4.83
37.3608	22.44	0.2007	2.40501	1.13
39.4030	35.17	0.2676	2.28494	1.77
40.2509	29.64	0.1004	2.23874	1.49
42.3882	94.51	0.1338	2.13067	4.75
47.4637	36.50	0.2342	1.91399	1.84
49.7905	127.83	0.2007	1.82986	6.43
51.9873	39.60	0.2676	1.75758	1.99
54.8027	62.56	0.1004	1.67376	3.15
59.8583	559.82	0.1004	1.54390	28.15
62.7393	33.27	0.2007	1.47976	1.67
65.9919	62.90	0.1004	1.41448	3.16
67.6257	42.27	0.1004	1.38423	2.13
68.0644	63.92	0.1004	1.37637	3.21
78.3026	85.25	0.1224	1.22004	4.29

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Fig-4: XRD analysis of Cement of (95% of HAC and rest 5% is Rice Husk)

Pos. [$^{\circ}$ 2 θ .]	Height [cts]	FWHM Left [$^{\circ}$ 2 θ .]	d-spacing [\AA]	Rel. Int. [%]
11.6285	152.28	0.2676	7.61013	1.28
18.3011	345.93	0.1338	4.84777	2.90
20.2845	150.52	0.2007	4.37802	1.26
20.8444	2568.71	0.1004	4.26167	21.56
22.0170	75.49	0.2007	4.03727	0.63
23.1742	171.01	0.1004	3.83822	1.44
23.5696	245.63	0.1004	3.77473	2.06
23.9713	191.32	0.1338	3.71238	1.61
24.8587	46.19	0.2676	3.58182	0.39
25.6773	201.71	0.1004	3.46946	1.69
26.6456	11913.85	0.1338	3.34554	100.00
27.4634	917.39	0.1673	3.24775	7.70
28.5929	1139.25	0.1004	3.12197	9.56
29.0960	195.07	0.1004	3.06912	1.64
31.3681	976.58	0.1338	2.85181	8.20
33.1077	544.53	0.1171	2.70583	4.57
35.0896	263.49	0.1338	2.55742	2.21
36.5352	507.78	0.1004	2.45948	4.26
37.4019	140.52	0.2007	2.40445	1.18
39.4372	935.77	0.1338	2.28493	7.85
40.2795	589.71	0.1004	2.23907	4.95
42.4206	640.75	0.1338	2.13089	5.38
44.3727	120.53	0.2007	2.04157	1.01
45.7721	433.91	0.1004	1.98235	3.64
47.5280	207.73	0.2676	1.91314	1.74
48.9592	47.68	0.4015	1.86051	0.40
50.1089	2290.79	0.1004	1.82048	19.23
51.9885	184.76	0.1338	1.75900	1.55
54.9030	323.73	0.2007	1.67232	2.72
55.3534	165.44	0.1338	1.65978	1.39
59.2486	105.92	0.2676	1.55962	0.89
59.9361	1663.67	0.1004	1.54337	13.96
63.7014	101.87	0.1224	1.45971	0.86
64.0138	177.95	0.1004	1.45454	1.49
67.7348	1189.39	0.2007	1.38341	9.98
68.2157	345.55	0.2676	1.37483	2.90
73.4510	89.61	0.1338	1.28923	0.75
75.8346	120.64	0.1224	1.25349	1.01

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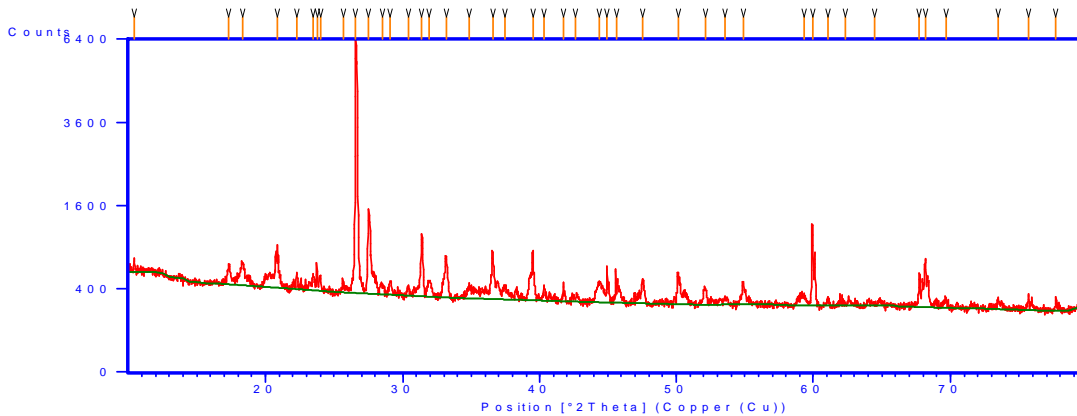


Fig-5: XRD analysis of Cement of (95% of HAC and rest 5% is Crusher Dust)

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
10.4518	164.34	0.1004	8.46410	2.92
17.3260	229.49	0.1673	5.11834	4.07
18.3258	248.46	0.2007	4.84130	4.41
20.9078	408.53	0.2342	4.24890	7.25
22.2983	150.59	0.1004	3.98697	2.67
23.4971	144.47	0.1338	3.78620	2.56
23.7650	176.61	0.1004	3.74413	3.14
24.0267	123.38	0.1171	3.70393	2.19
25.6573	84.85	0.2007	3.47213	1.51
26.5851	5632.72	0.1004	3.35302	100.00
27.5407	1090.40	0.1673	3.23881	19.36
28.4970	85.06	0.2007	3.13227	1.51
29.1230	129.21	0.1673	3.06635	2.29
30.4256	71.63	0.2007	2.93797	1.27
31.3936	755.36	0.1171	2.84955	13.41
31.9651	149.02	0.2342	2.79990	2.65
33.1581	440.47	0.1673	2.70183	7.82
34.8424	106.52	0.2007	2.57499	1.89
36.5642	486.07	0.1338	2.45759	8.63
37.4558	119.46	0.2342	2.40112	2.12
39.4857	480.15	0.1338	2.28223	8.52
40.3057	133.99	0.1004	2.23767	2.38
41.7720	115.45	0.1338	2.16246	2.05
42.6515	38.95	0.4015	2.11988	0.69
44.4158	173.51	0.4684	2.03969	3.08
44.9745	310.50	0.1004	2.01564	5.51
45.6729	140.66	0.3346	1.98643	2.50
47.5726	208.14	0.1673	1.91145	3.70
50.1398	307.48	0.1338	1.81943	5.46
52.1286	140.53	0.2007	1.75460	2.49
53.5866	44.93	0.4015	1.71025	0.80

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54.8799	207.93	0.1004	1.67297	3.69
59.3010	82.14	0.3346	1.55837	1.46
59.9819	554.43	0.2007	1.54230	9.84
61.0724	41.19	0.2007	1.51735	0.73
62.3504	22.99	0.8029	1.48928	0.41
64.4437	12.16	0.8029	1.44587	0.22
67.7307	318.83	0.1004	1.38349	5.66
68.1877	501.97	0.1004	1.37532	8.91
69.6878	51.43	0.2676	1.34934	0.91
73.4490	82.12	0.2007	1.28926	1.46
75.6719	113.96	0.1224	1.25578	2.02
77.6696	101.73	0.1224	1.22840	1.81

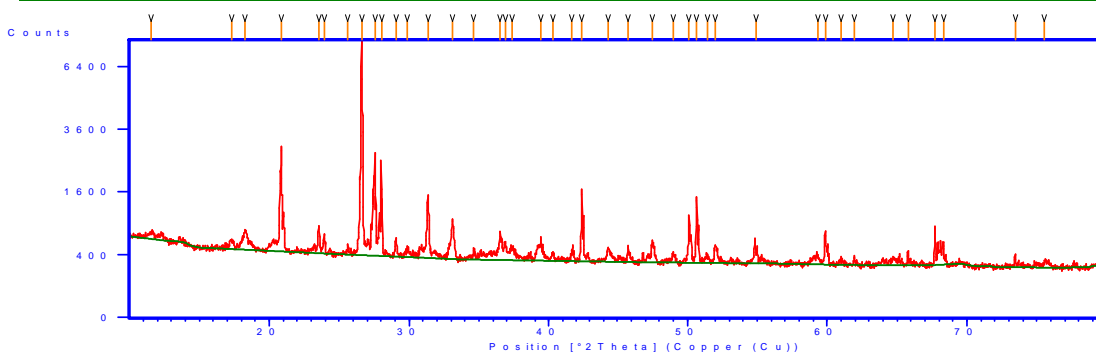


Fig-6: XRD analysis of Cement of (95% of HAC and rest 5% is Coconut Shell)

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
11.5499	103.27	0.4015	7.66176	1.52
17.3277	108.06	0.2007	5.11783	1.60
18.3090	310.82	0.1673	4.84570	4.59
20.8403	2186.05	0.1004	4.26251	32.28
23.5249	404.05	0.1004	3.78180	5.97
23.9605	254.85	0.1338	3.71403	3.76
25.6385	130.70	0.1004	3.47463	1.93
26.6313	6773.19	0.1338	3.34731	100.00
27.5551	1908.87	0.1673	3.23715	28.18
28.0370	1124.82	0.1004	3.18260	16.61
29.0864	252.35	0.1338	3.07012	3.73
29.8579	103.20	0.2676	2.99252	1.52
31.3461	1130.72	0.1004	2.85376	16.69
33.1261	592.86	0.1673	2.70437	8.75
34.6511	101.03	0.2007	2.58877	1.49
36.5222	404.03	0.1338	2.46033	5.97
36.8699	237.77	0.1004	2.43792	3.51
37.3905	157.21	0.2676	2.40516	2.32
39.4415	238.23	0.4015	2.28469	3.52
40.2834	88.42	0.2007	2.23886	1.31
41.7547	170.25	0.1673	2.16331	2.51
42.4339	1094.99	0.1004	2.13025	16.17

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44.3451	163.11	0.1673	2.04277	2.41
45.7579	175.88	0.2007	1.98294	2.60
47.4879	260.35	0.2007	1.91466	3.84
49.0248	98.68	0.2007	1.85817	1.46
50.1096	630.57	0.1004	1.82046	9.31
50.6489	987.53	0.1004	1.80233	14.58
51.4094	83.88	0.2007	1.77745	1.24
51.9591	206.06	0.1004	1.75993	3.04
54.8750	207.46	0.2007	1.67311	3.06
59.2993	106.11	0.2676	1.55841	1.57
59.8613	421.40	0.1004	1.54511	6.22
60.9775	63.19	0.2007	1.51948	0.93
61.9361	76.40	0.1004	1.49824	1.13
64.7242	80.01	0.6691	1.44028	1.18
65.8128	82.89	0.2007	1.41907	1.22
67.7271	341.05	0.2007	1.38355	5.04
68.3040	281.82	0.1171	1.37326	4.16
73.4425	129.05	0.1004	1.28936	1.91
75.5045	47.18	0.8029	1.25919	0.70

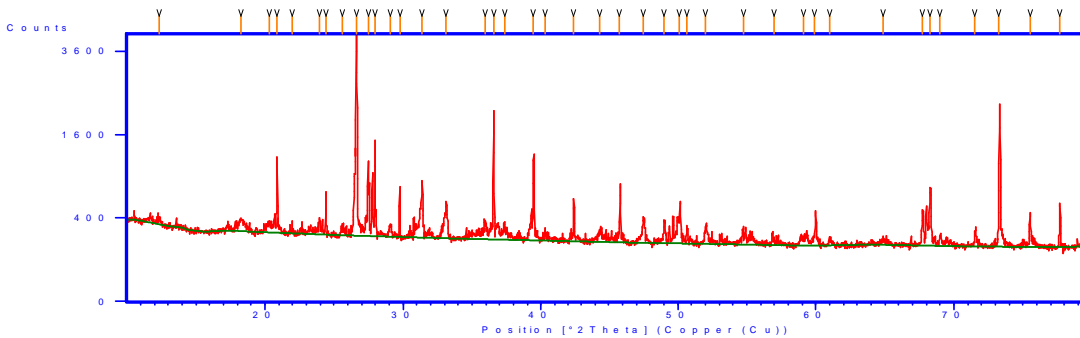


Fig-7: XRD analysis of Cement of (95% of HAC and rest 5% is Marble Dust)

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
12.3459	50.10	0.2676	7.16358	2.04
18.2408	105.41	0.2676	4.85964	4.29
20.2946	75.54	0.4015	4.37225	3.07
20.8926	507.56	0.1004	4.24844	20.65
21.9564	38.29	0.2007	4.04493	1.56
23.9689	110.59	0.1004	3.70967	4.50
24.4180	241.33	0.1004	3.64245	9.82
25.6060	61.62	0.2342	3.47609	2.51
26.6412	2458.33	0.1338	3.34331	100.00
27.5039	533.67	0.1004	3.24038	21.71
27.9896	454.68	0.1004	3.18524	18.50
29.1041	84.99	0.1338	3.06575	3.46
29.7640	161.10	0.1004	2.99926	6.55
31.3640	502.12	0.1004	2.84982	20.43
33.1531	251.53	0.1673	2.70000	10.23

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35.9574	115.53	0.2007	2.49560	4.70
36.5642	788.57	0.1004	2.45556	32.08
37.3787	92.85	0.2676	2.40390	3.78
39.4530	720.49	0.1004	2.28216	29.31
40.2835	51.05	0.2007	2.23700	2.08
42.4163	205.81	0.1004	2.12933	8.37
44.3642	76.30	0.2007	2.04025	3.10
45.7708	356.46	0.1004	1.98077	14.50
47.4982	160.27	0.1338	1.91268	6.52
48.9772	124.42	0.1673	1.85833	5.06
50.1233	226.53	0.2007	1.81849	9.21
50.6104	83.21	0.1004	1.80212	3.38
51.9912	109.63	0.1338	1.75746	4.46
54.7566	63.07	0.3346	1.67506	2.57
56.9717	29.06	0.4015	1.61508	1.18
59.1086	51.32	0.4015	1.56169	2.09
59.9155	185.22	0.1004	1.54257	7.53
61.0048	27.29	0.4015	1.51761	1.11
64.8518	30.72	0.5353	1.43657	1.25
67.6681	205.06	0.1004	1.38347	8.34
68.2208	429.70	0.1004	1.37360	17.48
68.9294	50.38	0.2007	1.36120	2.05
71.4750	90.02	0.1004	1.31884	3.66
73.2366	1337.61	0.1004	1.29141	54.41
75.5116	176.17	0.1224	1.25805	7.17
77.6435	163.61	0.2448	1.22874	6.66

V. RESULT OF COMPRESSIVE STRENGTH OF CUBES (15CMX15CMX15CM)

Compressive strength of HAC and HAC with different additives on 1 day, 3 days, 7 days, 14 days and 28 days are shown from table no. 1 to 31 and the same is represented in bar chart from chart no. 1 to 31.

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
24.5	32.25	27.24	24.23	20.43

Table No-1 (HAC-100%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
25.15	30.16	26.24	24.45	23.35

Table No-2 (HAC-97.5% and 2.5% of Fly Ash)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
23.67	30.87	28.23	24.76	21.43

Table No-3 (HAC-97.5% and OPC-2.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
24.5	30.32	25.89	23.69	20.78

Table No-4 (HAC-97.5% and Crusher Dust-2.5%)

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1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
20.5	28.31	25.56	23.56	20.89

Table No-5 (HAC-97.5% and Rice Husk-2.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
22.6	29.53	25.67	25.0	24.18

Table No-7 (HAC-97.5% and Marble Dust-2.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
22.2	28.7	29.3	33.15	36.4

Table No-9 (HAC- 95% and OPC-5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
19.7	29.5	26.7	25.8	24.6

Table No-11 (HAC-95% and Rice Husk-5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
21.5	28.74	29.0	31.23	33.75

Table No-13 (HAC-95% and Marble Dust-5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
21.25	26.23	31.67	34.85	38.67

Table No-15 (HAC-92.5% and OPC-7.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
18.75	27.2	29.5	31.4	36.9

Table No-17 (HAC-92.5% and Rice Husk-7.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
18.7	24.45	23.6	28.56	21.67

Table No-6 (HAC-7.5% and Coconut Shell-2.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
21.75	29.78	29.96	32.32	34.6

Table No-8 (HAC-95% and 5% of Fly Ash)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
20.5	26.4	24.5	31.67	34.4

Table No-10 (HAC-95% and Crusher Dust- 5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
18.0	25.10	24.21	23.23	24.0

Table No-12 (HAC-95% and Coconut Shell-5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
20.75	26.25	32.35	36.76	39.05

Table No-14 (HAC-92.5% and 7.5% of Fly Ash)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
19.0	25.4	26.3	34.5	37.6

Table No-16 (HAC-92.5% and Crusher Dust-7.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
17.25	23.5	28.2	30.4	34.5

Table No-18 (HAC-92.5% and Coconut Shell-7.5%)

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1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
20.75	27.23	31.5	35.25	38.0

Table No-19 (HAC-92.5% and Marble Dust-7.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
19.65	28.25	34.65	31.25	46.54

Table No-20 (HAC-90% and 10% of Fly Ash)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
19.05	29.25	36.75	43.5	47.25

Table No-21 (HAC-90% and OPC-10%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
17.05	28.45	34.3	37.5	40.6

Table No-22 (HAC-90% and Crusher Dust-10%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
17.90	31.56	36.8	37.45	39.87

Table No-23 (HAC-90% and Rice Husk-10%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
16.5	22.5	24.6	29.0	35.50

Table No-24 (HAC-90% and Coconut Shell-10%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
19.23	26.5	31.23	36.34	39.0

Table No-25 (HAC-90% and Marble Dust-10%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
14.25	19.65	24.32	29.45	37.98

Table No-26 (HAC-87.5% and 12.5% of Fly Ash)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
15.10	19.24	25.45	30.34	37.14

Table No-27 (HAC-87.5% and OPC-12.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
13.76	20.65	23.87	24.98	34.87

Table No-28 (HAC-87.5% and Crusher Dust-12.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
12.2	25.5	27.5	32.3	28.8

Table No-29 (HAC-87.5% and Rice Husk-12.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
13.5	21.56	24.01	28.32	29.76

Table No-30 (HAC-87.5% and Coconut Shell-12.5%)

1 st Day (N/mm ²)	3 rd Day (N/mm ²)	7 th Day (N/mm ²)	14 th Day (N/mm ²)	28 th Day (N/mm ²)
13.25	18.41	23.32	28.40	33.24

Table No-31 (HAC-87.5% and Marble Dust-12.5%)

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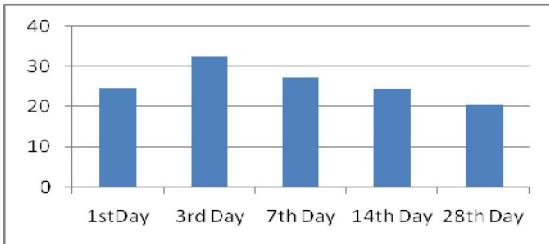


Chart-1 (HAC-100% and other ingredients-0%)

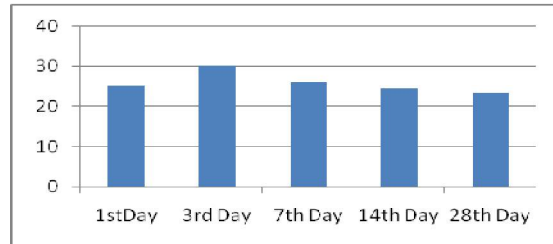


Chart-2 (HAC-97.5% and Fly Ash-2.5%)

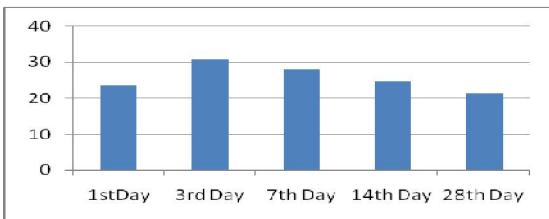


Chart-3 (HAC-97.5% and OPC-2.5%)

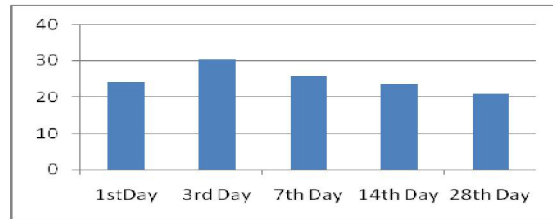


Chart-4 (HAC-97.5% and Crusher Dust-2.5%)

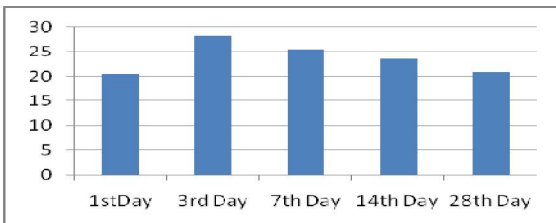


Chart-5 (HAC-97.5% and Rice Husk-2.5%)

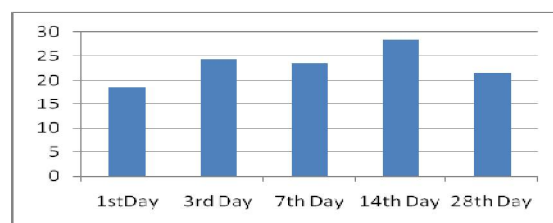


Chart-6 (HAC-97.5% and Coconut Shell-2.5%)

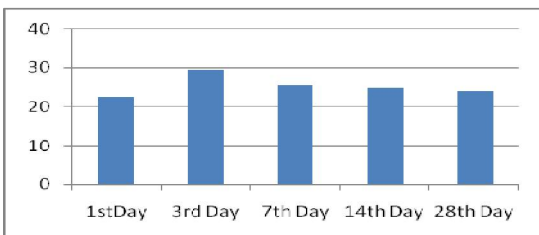


Chart-7 (HAC-97.5% and Marble Dust-2.5%)

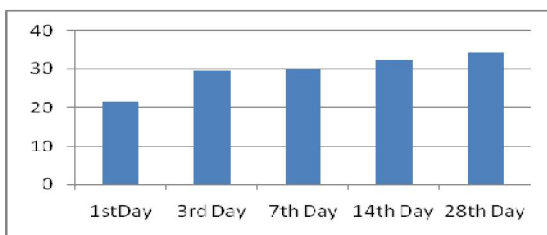


Chart-8 (HAC-95% and Fly Ash-5%)

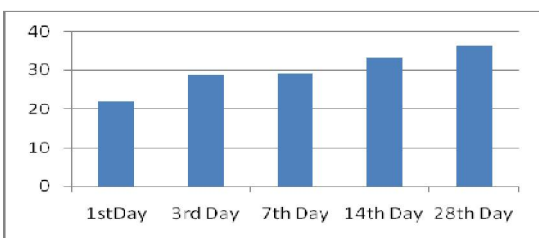


Chart-9 (HAC-95% and OPC-5%)

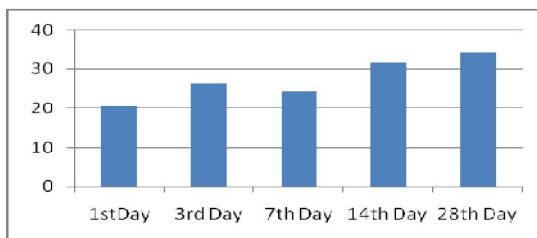


Chart-10 (HAC-95% and Crusher Dust-5%)

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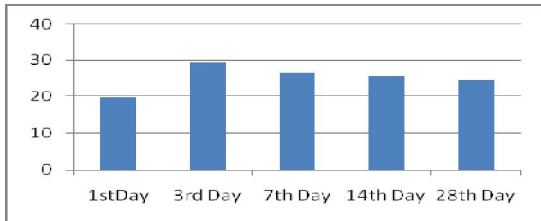


Chart-11 (HAC-95% and Rice Husk-5%)

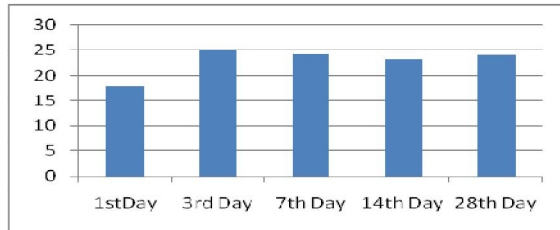


Chart-12 (HAC-95% and Coconut Shell-5%)

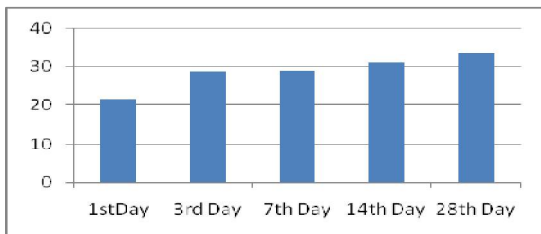


Chart-13 (HAC-95% and Marble Dust-5%)

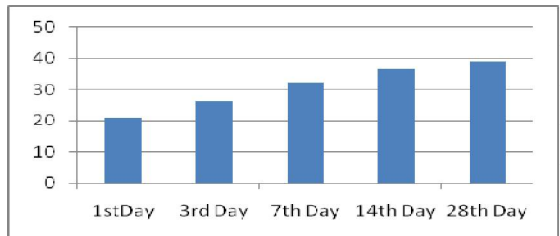


Chart-14 (HAC-92.5% and Fly Ash-7.5%)

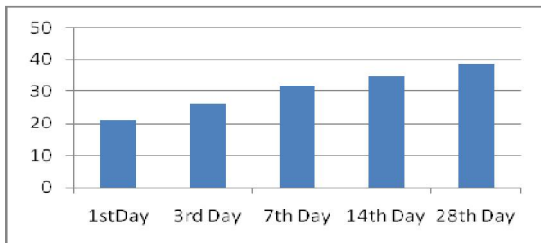


Chart-15 (HAC-92.5% and OPC-7.5%)

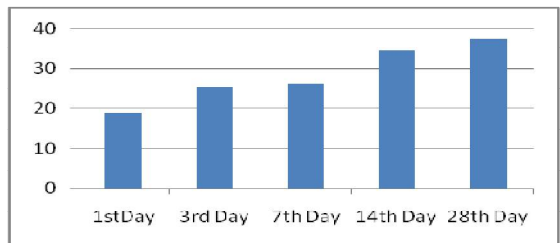


Chart-16 (HAC-92.5% and Crusher Dust-7.5%)

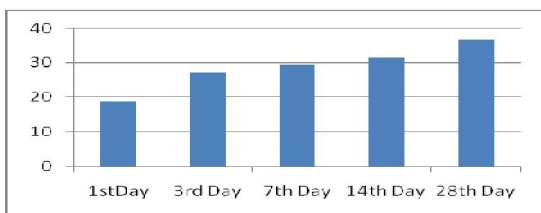


Chart-17 (HAC-92.5% and Rice Husk-7.5%)

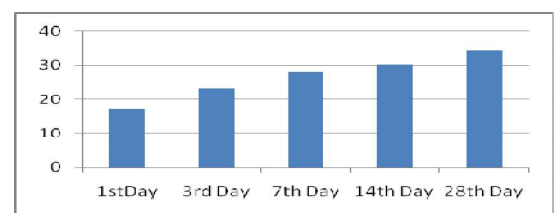


Chart-18 (HAC-92.5% and Coconut Shell-7.5%)

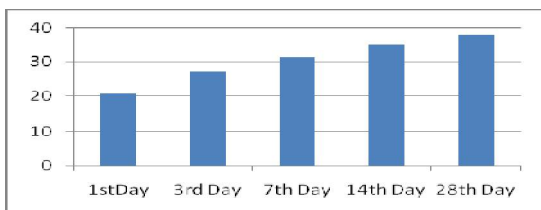


Chart-19 (HAC-92.5% and Marble Dust-7.5%)

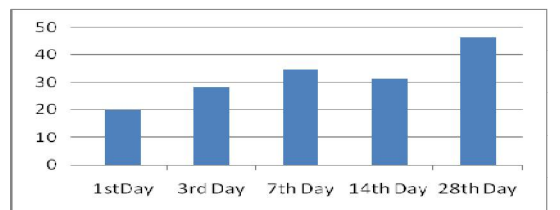


Chart-20 (HAC-90% and Fly Ash-10%)

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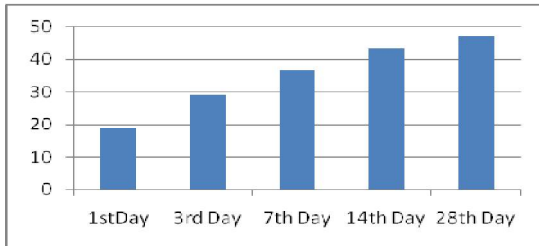


Chart-21 (HAC-90% and OPC-10%)

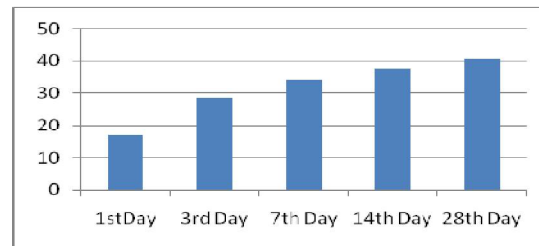


Chart-22 (HAC-90% and Crusher Dust-10%)

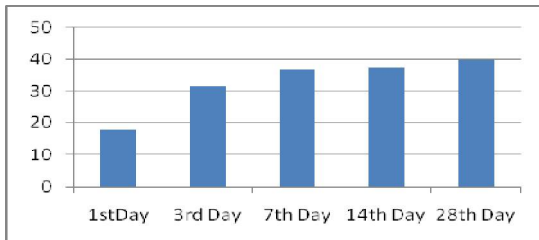


Chart-23 (HAC-90% and Rice Husk-10%)

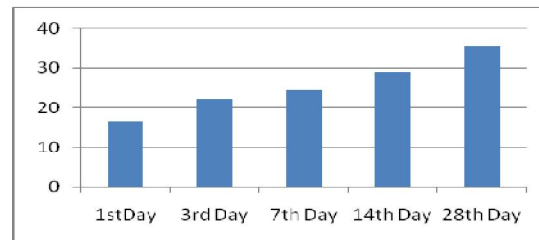


Chart-24 (HAC-90% and Coconut Shell-10%)

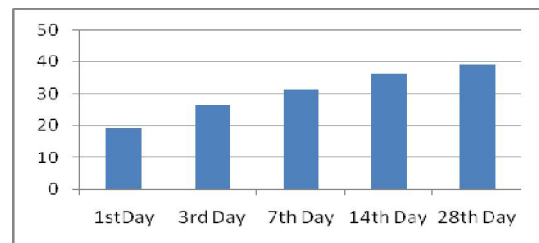


Chart-25 (HAC-90% and Marble Dust-10%)

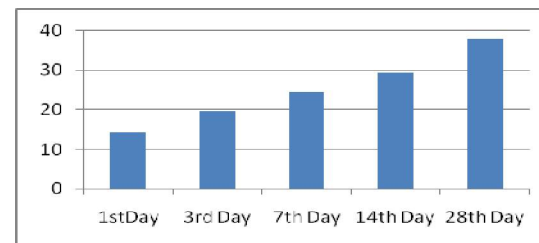


Chart-26 (HAC-87.5% and Fly Ash-12.5%)

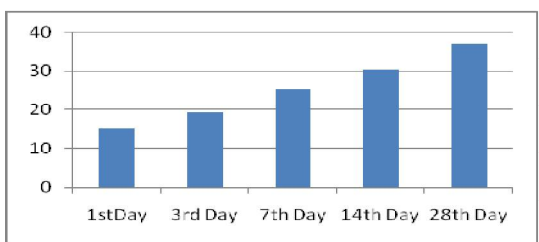


Chart-27 (HAC-87.5% and OPC-12.5%)

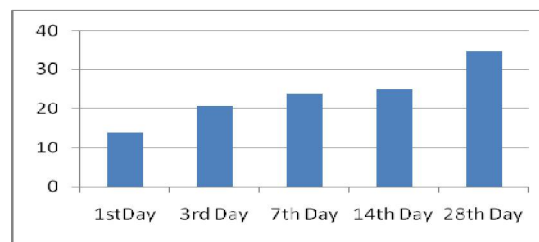


Chart-28 (HAC-87.5% and Crusher Dust-12.5%)

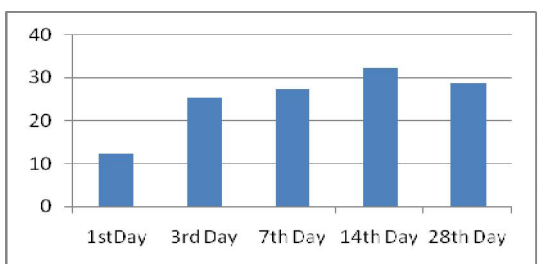


Chart-29 (HAC-87.5% and Rice Husk-12.5%)

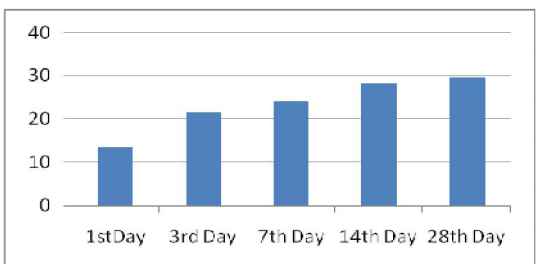


Chart-30 (HAC-87.5% and Coconut Shell-12.5%)

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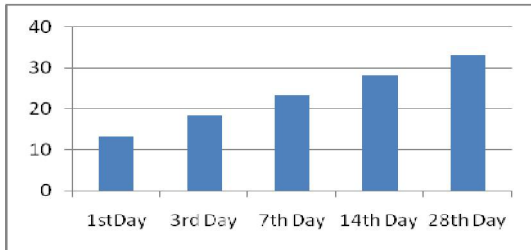


Chart-31 (HAC-87.5% and Marble Dust-12.5%)

VI. RESULT DISCUSSION

28 DAYS COMPRESSIVE STRENGTH OF HAC REPLACING WITH DIFFERENT INGREDIENTS

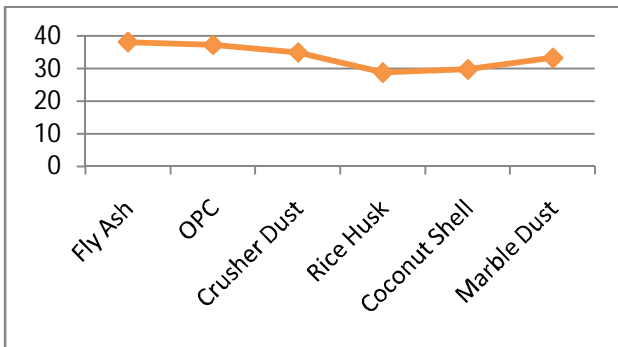


Chart -32 (HAC-97.5% and other ingredients are 2.5%)

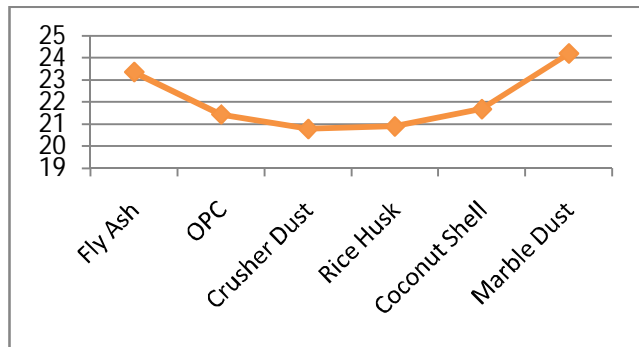


Chart -33 (HAC-95% and other ingredients are 5%)

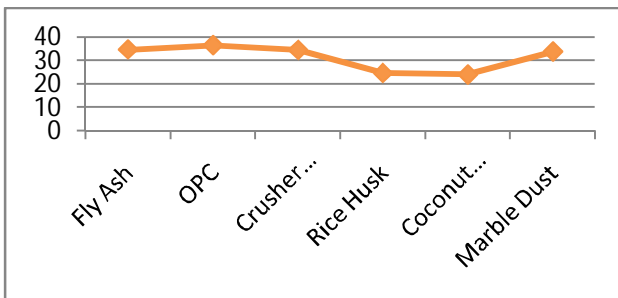


Chart -34 (HAC-92.5% and other ingredients are 7.5%)

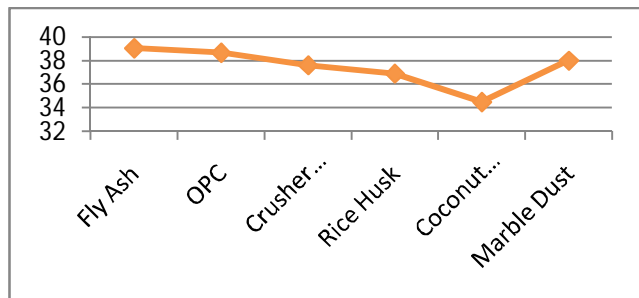


Chart -35 (HAC-90% and other ingredients are 10%)

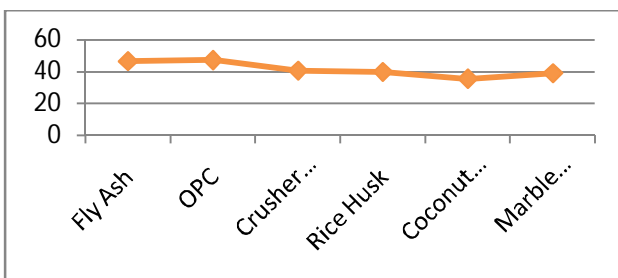


Chart -36 (HAC-87.5% and other ingredients are 12.5%)

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From the graph 32 to 36 it is concluded that, at low ambient temperature, HAC cement may give high early strength. The usual strength of HAC is much affected by the hydration due to exothermic reaction as conventional casting temperature is more than 20°C in tropical climate since CAH_{10} and C_2AH_8 are the dominant hydration products. The strength of HAC concrete initially under this condition may drop significantly due to conversion of CAH_{10} and C_2AH_8 to C_3AH_6 , when the ambient temperature increases. This conversion occurs due to exothermic reaction in the fresh concrete mass which may be controlled by using different ingredients like **Fly-ash, OPC, Crusher Dust, Rice Husk, Coconut Shell and Marble Dust**. The attainment of compressive strength of HAC concrete is very less when only HAC cement is used in the mix without adding any ingredient, as conversion reaction in the concrete mass at mixing temperature is 38°C and curing temperature is at 25°C. But, when **Fly-ash, OPC, Crusher Dust, Rice Husk, Coconut Shell and Marble Dust** ingredients are added with gradually variation of 2.5%, 5%, 7.5%, 10% and 12.5% for each additive by weight of High Alumina Cement under a fixed proportion of water, urea, silica zel, tri-calcium orthophosphate, sodium hexa-meta phosphate and admixture being maintained at 40%, 0.0625%, 0.125%, 0.25%, 0.5% and 0.4% respectively in all cases, it is found that maximum 28 days strength is attainable at 10% replaced mix as per the cube test results.

VII. CONCLUSIONS

It is concluded that the additive materials like Fly-ash, OPC, Crusher Dust, Rice Husk, Coconut Shell and Marble Dust individually added with 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 and XRD investigations are required.

ACKNOWLEDGMENTS

I would like to thank Prof. (Dr.) M K Dash of IGIT Sarang for his inspiration, guidance and support for the project work. Sincere thanks to all the staff members of our department for their immense support during the project work.

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