Experimental Investigation of Concrete with Combined High alumina cement, Silica fume and M-Sand

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ABSTRACT

Concrete is by far the most widely used construction material today. It is estimated that present consumption of concrete in the world is of the order of 10 billion tonnes every year. The cement industry is responsible for about 6% of all CO_2 emissions. So nowadays there is a great interest in the development and implementation of various alternatives to Portland cement as a binder in concrete and also alternatives to fine and coarse aggregates in concrete to reduce the energy used in production of Portland cement clinker and the associated greenhouse gas emission and also for reducing resources consumption by proper recycling. This research work is carried out in order to explore the effect of various replacement percentages of cement by combined High alumina cement with silica fume and also the fine aggregate is fully replaced with manufacturing sand. Conclusion is made based on the comparison between the performance of blended cement concrete and conventional concrete.

Keywords **–** Concrete, High Alumina Cement, Manufacturing sand, Silica fume

1. INTRODUCTION

The development of smart concretes with non-Portland cement results from the emergence of a new science of concrete, a new science of admixture and the use of sophisticated scientific apparatus to observe concrete microstructure and even nanostructure.

Blended hydraulic cement having a normal setting character but rapid gain is a mixture of Portland cement and high alumina cement with other admixtures in order to accelerate early strength and prolonged setting time.

The implementation of alternatives to Portland cement as a binder in concrete is very much helpful to reduce the energy used in the production of Ordinary Portland cement and the associated green house gas emission. High Alumina Cement (HAC) is a special type of non-Portland cement. An increase in usage of HAC is extensively observed in recent past combining it with other binder systems even for day today application. An Ordinary Portland cement (OPC) and one or some mineral/chemical admixture usually serves as a mixer binder. The replacement of HAC by Portland cement may develop a high early strength. The substitution of admixture in this mix may develop a compressive strength higher than or equal to that of HAC under normal circumstances. Silica fume (SF) is preferred because it is highly pozzolanic due to its particle nature which improves the properties concrete Silica fume (SF) performs mainly two functions. The additional C-S-H produced by silica fume is more resistant to attack from aggressive chemicals. Another function silica fume performs in cementitious compounds is a physical one as a filler. As silica fume is 100 to 150 times smaller than cement particle it can fill the voids created by free water in the matrix. Also It is an eco friendly material. Calcium aluminate concrete or high alumina concrete is said to undergo a process called conversion due to which the strength reduces over time. This conversion can take place in just few hours or in several years depending upon the temperature. This is the main reason why calcium aluminate concrete is not used for structural purpose. However the porosity caused due to conversion can be reduced by the addition of silica fume.
The need for crusher sand is increasing these days as the cost of natural sand is becoming high day by day as there is a scarcity and also there is a need to safeguard the natural resources for future generation.

Table 1: Chemical Composition of Elements by EDX (Energy Dispersive X- Ray Spectroscopy)

Materials	**Oxides expressed in percentage (%)**							
	CaO	**Al_2O_3**	**SiO_2**	**Fe_2O_3**	**MgO**	**Na_2O**	**SO_3**	**LOI**
HAC	**38.27**	**39.58**	**3.87**	**15.02**	**0.1**	**0.1**	**0.15**	**0.72**
OPC	**63.41**	**6.14**	**21.44**	**3.15**	**0.96**	**0.26**	**2.82**	**0.8**
SF	**0.45**	**1.17**	**92.7**	**3.13**	**0.3**	**0.2**	**0.1**	**2**

2. SEM ANALYSIS

A **scanning electron microscope** (**SEM**) produces images of a sample by scanning it with a focused beam of electrons. These electrons interact with electrons in the sample, producing various signals which contain information about the sample's surface topography and composition. SEM can achieve resolution better than 1 nanometer.

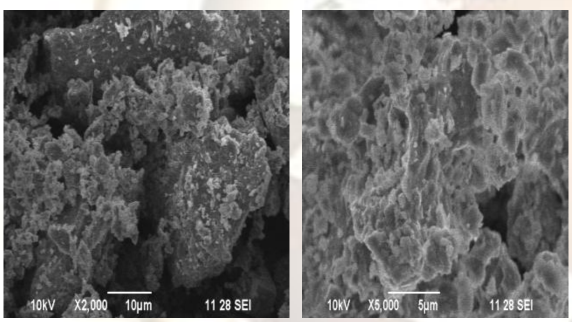

Fig 1: sem images of calcium aluminate cement

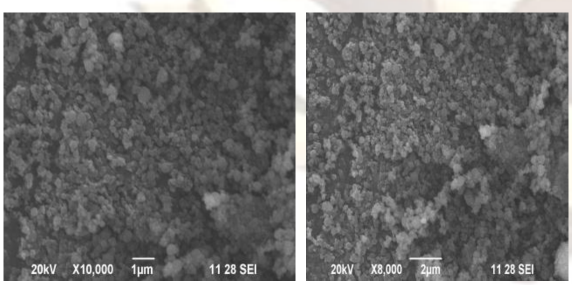

Fig 2: Sem images of silica fume

3. MIX DESIGN

The details of the mix design are given in table 2.

Table 2 : Mix Design Calculation for M25 and M30 Grade Concrete Using IS 10262:2009

material	M25		M30	
	Quantity (Kg/m^3)	Mix ratio	Quantity (Kg/m^3)	Mix ratio
Cement	425.78	1	445	1
Fine aggregate	685	1.6	670	1.5
Coarse aggregate	1209	2.8	1186	2.6
Water	191.6	.45	191.6	.43

4. EXPERIMENTAL INVESTIGATIONS

Basic tests to find out the physical properties of various ingredients in blended cement concrete have been conducted to continue the thesis. The results of the various tests are tabulated and the comparisons are produced in graphical form in the following session.

4.1. Consistency Test

Table 3 : consistency test results

Components	**value**
Ordinary Portland cement	32%
High Alumina Cement	36%

4.2.Initial Setting Time

Table 4 : Initial setting time result

Components	Value
Ordinary Portland cement	30 minutes
High Alumina Cement	80 minutes
Blended cement (30% OPC + 60% HAC + 10% Silica fume)	100 minutes

4.3 Properties of Fine Aggregate

Table 5: Properties of fine aggregate

Property	River Sand	M-Sand
Specific gravity	2.68	2.66
Loose density	1.57 g/cc	1.64 g/cc
Rodded density	1.72 g/cc	1.89 g/cc
Grading Zone	II	II

4.4 Properties of Coarse Aggregate

Table 6: Properties of coarse aggregate

Property	Coarse aggregate
Specific gravity	2.9
Density	1.47 g/cc

4.5 Tests on Strength

4.5.1 Compressive Strength of Cement (N/mm^2)

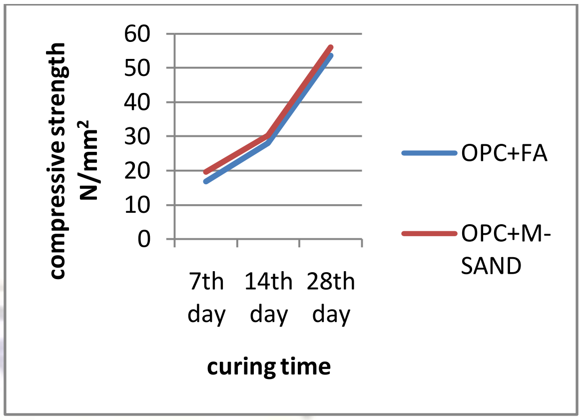

Fig 3: Comparison of strength development of Cement using river sand and M-Sand

Fig 4: compressive strength of cement testing setup

4.6.2 Compressive Strength of Concrete (N/mm^2)

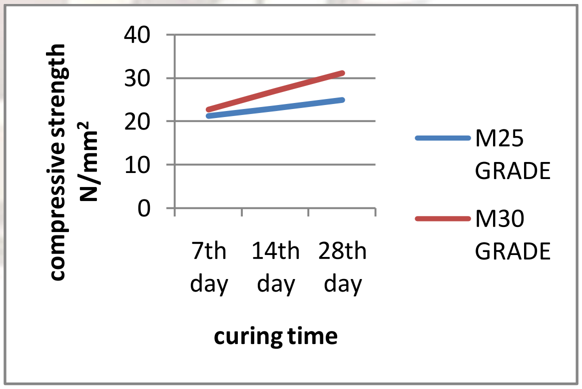

Fig 5: Comparison of Cylindrical compressive Strength development of normal concrete

Fig 6: cylindrical compressive strength of concrete testing setup

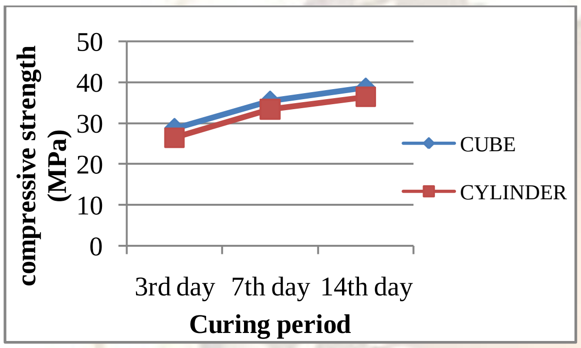

Fig 7: Strength development of concrete using blended cement with M-Sand

4.6.3. Test on Durability – Alkalinity Test

Table 7: pH value of concrete

Concrete grade	pH value
M25	11.2
M30	11.7
blended cement concrete	11.9

3. Conclusion

Blended cement concrete is developed with the mixture of Ordinary Portland cement, High Alumina cement, M-sand, coarse aggregate with conplast SP430 super plasticizer for the purpose of accelerating early strength and prolonged setting time. The initial setting time of this blended cement is extended to 100 minutes permitting enough time for batching, placing and finishing of concrete perfectly at site. This blended cement will set fastly that the time between initial and final set is found to be about 10-12 minutes. Strength development rate after hardening is fast and after 3 days of curing, compressive strength exceeding 28.8 MPa and 26.51 MPa for cube and cylindrical specimens were obtained. This is similar to what the conventional concrete achieves in 28 days. Nearly 20% of compressive strength of Portland cement is increased by using M-Sand for river sand in conventional concrete.

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