AN EXPERIMENTAL INVESTIGATION OF REPLACEMENT OF SILICA FUME ALONG WITH HYDRATED LIME IN CONCRETE

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ABSTRACT: The aim of this study is to calculate the performance of replacement of Silica fume and hydrated lime Sustainability is considered to be highly important for preserving continued industrial growth and human development. To overcome this environmental degradation, silica fume and hydrated lime are used as partial replacements of cement. This paper begins with the experimental investigation of silica fume along with hydrated lime and deals about their physical and chemical properties along with their strength parameters. Hydrated lime did not signify the major contribution in the development of strength. The silica fume which is the industrial - by product found to be an attractive cementitious material which is by product of melting process in the silicon and ferrosilicon industry. The partial replacement of silica fume and hydrated lime its effects on concrete properties has been studied by adopting M-20 grade concrete mix in this dissertation. The main parameter investigated in this study M-20 concrete mix with partial replacement by silica fume and hydrated lime with varying 0, 5, 10, and 15% by weight of cement. The paper presents a detailed experimental study on compressive strength for 7, 14 and 28 days respectively. The results of experimental investigation indicate that the use of silica fume and hydrated lime in concrete has increased the strength and durability at all age when compared to normal concrete. Hence the use of Silica Fume and hydrated lime leads to reduction in cement quantity for construction purpose and its use

should be promoted for better performance as well as for environmental sustainability.

KEYWORDS:-Silica Fume, hydrated lime, Compressive Strength

I. INTRODUCTION

Recent developments in the construction industry have promoted concrete as ‘highly efficient material with improved mechanical properties and durability’. It has been claimed that up to 5 – 9% of the total global anthropogenic carbon emissions [2, 3] are due to manufacturing of cement and concrete. Furthermore, concrete is not an unending building material when analyzed against time. Eventually, the life cycle of concrete will end up as limestone, sand and clay within our earth’s environment. From the idea of sustainability in concrete manufacturing, there is a need to develop an environmentally friendly type building material which ensures a good balance between performance and sustainability concern. With the extensive use of Portland cement, it is inevitable that such idea of sustainable concrete can be accomplished. However, if the cement manufacturing is tend to shift with the mixture of ‘second generation’ or ‘low carbon’ binders, the idea of achieving sustainable concrete may emerge to existence. In various recent studies, it has been addressed that hydraulic lime and supplementary cementitious materials (SCMs) do possess essential properties that leads towards strength development and enhancement of durability of concrete. Hydraulic lime, being one of the oldest binders contributes important history in construction practices and manufacturing process of concrete. Furthermore, SCMs broadly pozzolans, have also been considered as a viable approach to be used as an alternative binder. Pozzolans normally results in poor performance and low strength development at early stages due to absence of adequate quantities of

$Ca(OH)_2$. By adding hydrated lime the strength development and durability, possibilities for improving the pozzolanic reaction can be overcame.

Silica fume, being one of the most popular pozzolans is considered to play a vital role in developing strength, durability characteristics and consuming calcium hydroxides during the hydration reaction of Portland cement. Therefore, such pozzolanic reactions may contribute to lower heat liberation, adequate early strength development, effective consumption of hydrated lime and enhancement in durability characteristics.

Therefore, the aim of this paper is to offer a significant approach of using hydrated lime and silica fume as partial replacement of ordinary Portland cement as binders. The idea is to look into the possible way for replacement of hydrated lime and silica fume used as a partial replacement to cement on the strength development. Strength development includes compressive strength test as a key parameter being investigated.

II. LITERATURE SURVEY

Abdulazi.A et.al investigated that the advantages of using micro silica can be considerable as it reduces thermal cracking caused by the heat of cement hydration and can improve durability to attack by sulphate and acidic water, giving increase in performance of concrete. The optimum replacement of cement by silica fume gave high durability, permeability, high compressive strength.**Debarata Pradhan and D.Dutta** investigated the effects of silica fume on conventional concrete, concluded the optimum compressive strength was obtained at 20% cement replacement by silica fume at 24 hours, 7days and 28 days. Higher compressive strength resembles that the concrete incorporated with silica fume was high strength concrete. **Ram Kumar and Er.Jitender Dhaka** illustrated that the achievement of the present study obtained with the replacement of cement by 5%,9%,12% and 15% silica fume. The Compressive strength, split tensile strength and the flexural strength test were observed for the mixes at the age of 7 days and 28 days. Thus high performance concrete obtained by replacement of cement up to 12% silica fume leads to increase in compressive strength, and the flexural strength of concrete. The compressive strength mainly depend on percentage of silica fume. The percentage of increase in compressive strength is 17.76%, split tensile strength 20.74% and the flexural strength is 40.67%at the age of 28 days by replacing partial replacement of cement with silica fume.

III. MATERIAL USED:

1. CEMENT

Cement is a binding material which comprises of lime (CaO), Silica (SiO_2), Alumina (Al_2O_3) and Ferric Oxide (Fe_2O_3) along with some minor oxides. Portland cement exhibits various properties and functional requirements such as strength, durability and impermeability. The color of the cement is grey. The 53 Grade ordinary Portland cement is used for the test. The specific gravity of the cement is determined as 3.12. The initial setting time of cement is 30minutes and final setting time of cement is 600 minutes determined by using the VICAT apparatus. The fineness modulus of the cement is 3.3. The consistency of the cement is 33.

Fig.1. Ordinary Portland cement

2. 2. FINE AGGREGATE

The fine aggregates obtained from the river beds were used. The fine aggregate passing through 4.75mm sieve was used. The specific gravity of the fine aggregate is determined as 2.67. The percentage of water absorption is 1%. The fineness modulus is obtained as 2.67. The appearance of the fine aggregate is brownish yellow.

Fig.2. Fine Aggregate

3. 3. COARSE AGGREGATE

Coarse aggregate of size 10mm & 20 mm of crushed stone locally available confirming to IS 383-1987 was used.

Fig.3. Coarse Aggregate

Water:

The water used in this study was free of alkalis, acids, salts, organic materials & other impurities.

Silica Fume:

Silica fume is a byproduct of Ambuja Cement Limited & brought from astra chemical product limited, no: 532, vangaram road, Athipet, Ambattur, and Chennai.

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Fig.4. Silica fume

Hydrated lime:

It is an inorganic compound that is a colorless white crystal or powder. It is a byproduct of Abuja Cement Limited & brought from astra chemical product limited, no: 532, vangaram road, Athipet, Ambattur, and Chennai.

Fig.5. Hydrated lime

IV. EXPERIMENTAL INVESTIGATION

Mix Proportion:-

Table1: Silica Fume Concrete Mix

Mix	Percentage Of Silica Fume (%)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water Cement Ratio (Ml)
Mx0	0	1.36	3.0	5.6	0.45
Mx1	5	1.29	3.0	5.6	0.45
Mx2	10	1.22	3.0	5.6	0.45
Mx3	15	1.15	3.0	5.6	0.45

Table2: Hydrated lime Concrete Mix

Mix	Percentage Of Hydrated lime (%)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water Cement Ratio (Ml)
Mx4	5	1.29	3.0	5.6	0.45
Mx5	10	1.22	3.0	5.6	0.45
Mx6	15	1.15	3.0	5.6	0.45

Table3: Silica Fume & hydrated lime Concrete Mix

Mix	Percentage Of (%)		Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water Cement Ratio (Ml)
	SF	HL				
Mx7	5	10	1.15	3.0	5.6	0.45
Mx8	10	5	1.15	3.0	5.6	0.45
Mx9	15	15	0.95	3.0	5.6	0.45

CASTING OF SPECIMEN

1. ***Mix Proportion:*** Mix proportioning by weight was used in concrete mix design in this experiment was designed as per table for given in IS 10262.

2. ***Casting of Specimen:*** The following mould for casting the specimen were used

- The specimen of standard cubes of (150 mm x 150 mmx 150 mm) was used to determine the compressive strength.

Total 30 Cubes were casted for the strength parameters. The constituents were waved and the materials were mixed by hand mixing. The concrete was filled in different layer and each layer was compacted. The specimens were demoulded after 24 hours cured in water for 7, 14 & 28 days. Thus tested for its compressive strength as per Indian standard.

Fig.6. Casting of Specimen

V. TEST RESULT

Results of fresh and hardened concrete with partial replacement of Silica Fume and Hydrated Lime are discussed in comparison with those of normal concrete:

Compressive Strength:

The test was carried out conforming to IS 516-1959 to obtain compressive strength at the age of 7, 14 and 28 days. The cubes were tested using Compression Testing Machine (CTM) of capacity 2000 KN.

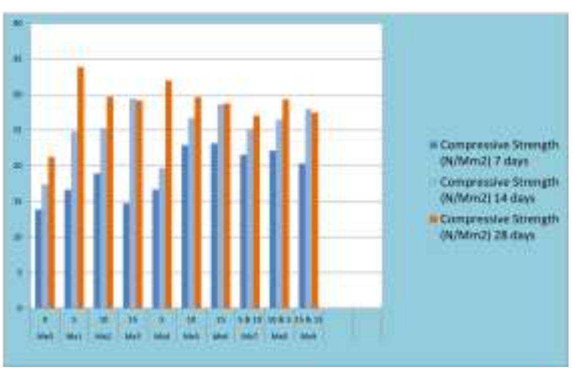
Fig.7. 7th day test a) before test b) after test

Fig8. 14th day test a) before test b) after test

Fig 9. 28th day test a) before test b) after test

Table4: Result of compressive strength

	Combinations of Silica Fume + Hydrated lime (%)	Compressive Strength (N/Mm^2)		
		7 days	14 days	28 days
Mx0	0	13.86	17.39	21.23
Mx1	5	16.64	24.84	33.86
Mx2	10	18.93	25.3	29.68
Mx3	15	14.75	29.42	29.15
Mx4	5	16.67	19.67	31.93
Mx5	10	22.89	26.72	29.64
Mx6	15	23.15	28.62	28.74
Mx7	5 & 10	21.56	25.19	27.02
Mx8	10 & 5	22.13	26.49	29.31
Mx9	15 & 15	20.33	27.96	27.45



The compressive strength as shown in above parameter up to 16.64 N/mm², 24.84 N/mm² & 33.86 N/mm² at 7, 14 and 28 days. There is a significant improvement in the compressive strength of concrete.

The compressive strength with partial replacement of cement by silica fume increased 5% and then decreased in all mix ratios or mix design.

VI. CONCLUSION

High performance concrete produced by partial replacement of cement with silica fume and hydrated lime in this study. The achievement of the present study obtained with the replacement of cement by 5%, 10% and 15% silica fume and hydrated lime the compressive strength test were observed for the mixes at the age of 7 days, 14 days and 28 days. Thus high performance concrete obtained by replacement of cement up to 5% silica fume and leads to increase in compressive strength, the compressive strength mainly depend on percentage of silica fume and hydrated lime. High performance concrete with silica fume and hydrated lime can be effectively used in high rise building since high early strength is required with the reduced construction period.

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