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Study on Performance of Activated Fly Ash and Silica Fume in High Performance Concrete

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Abstract - *Concrete in the sense a material which can resist large amount of compressive stresses. This property of concrete has multiplied its use in various construction activities. The conventional concrete has been modified by incorporating supplementary materials of the basic ingredients of the concrete. The main objective of doing so is to enhance the strength development by accelerating the hydration process and to increase the performance & durability of the concrete in its fresh and harden state. In this study an attempt is made to enhance the above-mentioned properties of concrete by adopting fly ash and silica fume as partial supplements of cement. The chemical and thermal activation of fly ash is done to increase the involvement to fly ash particles in the hydration process at early age of curing. Three concrete mixes were prepared by partially replacing the cement by silica fume and fly ash at 5% SF & 10% FA in Mix I, 7% SF & 20% FA in Mix II and 9% SF & 30% FA in Mix III. The slump cone test was performed to check the workability and compressive strength test was conducted to determine the strength. The results show that the chemically activated fly ash concrete mix develops higher strength.*

Key Words: Thermal activation, Chemical activation, Silica fume (SF) and Fly ash (FA).

1. INTRODUCTION

Concrete is one of the most abundantly used composite construction material on this green planet, earth. Among variety of concretes available, High-Performance Concrete is the one, which is widely used, is all type of construction activities. The idea of high strength and better durability of concrete can only be achieved by reducing the porosity, in homogeneity, micro cracks and transition zones [1]. Any concrete, which develops higher strength at the early age of curing and have long lasting durability could be called as High-Performance Concrete (HPC). In order to achieve the high performance, the concrete has to be blended with such a material so that after setting concrete transforms in to a nonporous solid material. This is achieved only by incorporating the mineral admixtures. Coal Fly ash and Silica fume are the mineral admixtures produced as an industrial waste product that can be used in the concrete as a partial replacement of cement to manufacture HPC.

India is the second largest coal consumer in the world. The 70% of the total coal consumption in the country accounts for power generation [2]. As industries grow, power consumption is going to increase and results in consumption of huge quantity of coal. The ash that flew away during the combustion of coal is captured by electrostatic precipitators or other filtration equipment is termed as Fly ash. It is the solid waste produced by the industries. The fly ash has as particle size in between 0.5 μm to 300 μm and contains substantial amounts of silicon dioxide, aluminium oxide and calcium oxide. The major constituents of the fly ash help to use it as a replacement for cement. By using the fly ash in concrete manufacture will help in the solid waste management and reducing environmental impacts.

Silica Fume is the by-product resulting from reduction of quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. Silica Fume consists of ninety percent of silica fume with remaining portion as carbon, sulphur, oxides of aluminium, iron, calcium, magnesium, sodium and potassium. Particle size of silica fume is in between 0.1μm to 0.2μm with surface area of 30,000 m^2/kg [3]. Because of its composition Silica Fume can be used as artificial pozzolanic admixture to obtain high strength of concrete. When both Fly ash and Silica Fume are used for partial replacement of cement at different percentages concrete with high early strength and long-lasting durability is obtained.

2. Objectives

- Activation of fly ash by means of thermal and chemical methods.
- To investigate the fresh concrete properties of high-performance concrete through workability test for different proportions of silica fume.
- To observe the influence of silica fume and activated fly ash on hardened concrete properties such as compressive strength etc. under different curing conditions.
- To arrive at optimum dosage of silica fume and fly ash in HPC.

3. Supplementary Material of Cement

3.1 Fly ash

Fly ash/flue ash is popularly known as pulverized fuel ash in UK. It obtained as the byproduct of coal combustion in thermal power plants. It is composed of the fine particles of burned coal that are driven out of coal-fired boilers. The ash that settles at the bottom of boiler's combustion chamber is called as coal bottom ash and ash that flew away is known as fly ash. In modern thermal power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment. Based upon the composition of coal and source of the coal, the components of fly ash generated vary considerably. But all fly ash includes substantial amounts of aluminum oxide (Al2O3) silicon dioxide (SiO2) in both amorphous and crystalline form and calcium oxide (CaO). On account of pozzolanic properties of fly ash, it is adopted as replacement of Portland cement in concrete. As pozzolanic properties of flew ash improves the strength development and durability of concrete. Hence, fly ash can be used in concrete to reduce the production of cement and carbon dioxide emission can be controlled. The fly ash can be used as supplementary cementitious material up to 30% of mass of cement. The fly ash concrete achieves greater compressive strengths at the later stages of curing

3.2 Silica fume

The byproduct in the production of silicon metal or ferrosilicon alloys is Silica fume. The silica fume is one among beneficial byproduct that is used in the concrete industries, especially in the manufacture if the high-performance concrete. This has become a very reactive pozolona mainly because of its physical and chemical properties. The concrete manufactured by adopting silica fume has very high strength at early ages and of highly durable one. Silica fume has non crystalline silicon dioxide (SiO2 amorphous) hence special attention is required while Placing, finishing, and curing of silica-fume concrete. The particle size of the silica fume is very small in comparison win cement particle about 1/100th of cement particle. It has got a very large surface area because of its fine particles and very high silicon dioxide content hence it is a very reactive pozzolana when used in concrete. The quality and guidelines for the use of silica fume is specified by AASHTO M 307 and ASTM C 1240. A concrete designer should make a conscious decision whether to incorporate it in to concrete or not to achieve required concrete properties as it requires more water. Silica fume can be used in concrete in wet form or in dry form. Based on the concrete properties required, silica fume is used as partial replacement of cement or it is added in addition to cement.

Table -1: Mix Design

Materials	Mix I 5% SF & 10% FA	Mix II 7% SF & 20% FA	Mix III 9% SF & 30% FA
Cement (kg/m^3)	449.50	386.03	322.57
Water (kg/m^3)	171.86	171.86	171.86
FA (kg/m^3)	528.37	575.97	570.50
CA (kg/m^3)	1143.22	1130.66	1119.90
HRWRA (kg/m^3)	2.64	2.64	2.64
W/C	0.325	0.325	0.325
SF (kg/m^3)	26.44	37.01	47.59
FA (kg/m^3)	52.88	105.76	158.64

CA-Coarse aggregate, FA-Fine aggregate and HRWRA-High Range Water Reducing agent.

4. Methodology

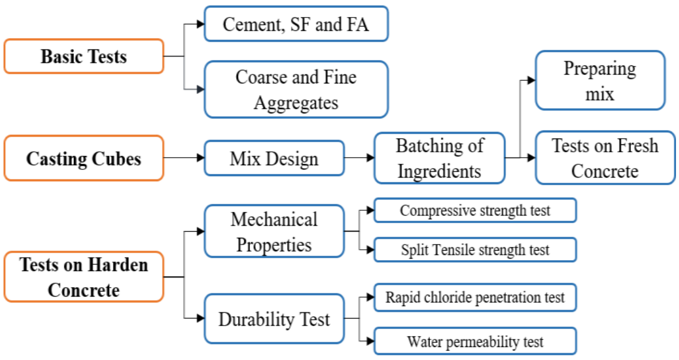

Chart -1: Methodology

5. Compression Test Results

The cubes of 150mmX150mmX150mm were casted for compression test. Nine specimens for each mix were casted i.e., 9 specimens of 5% SF & 10% FA (Mix I, Thermal activation), 9 specimens of 7% SF & 20% FA (Mix II, Thermal activation) and 9 specimens of 9% SF & 30% FA (Mix III, Thermal activation) were casted. Similarly, 9 specimens of each mix design were casted for chemical activation and 9 specimens of controlled mix were casted. Totally 63 specimens were casted and tested under compressive testing machine. The results of the test are graphically represented below.

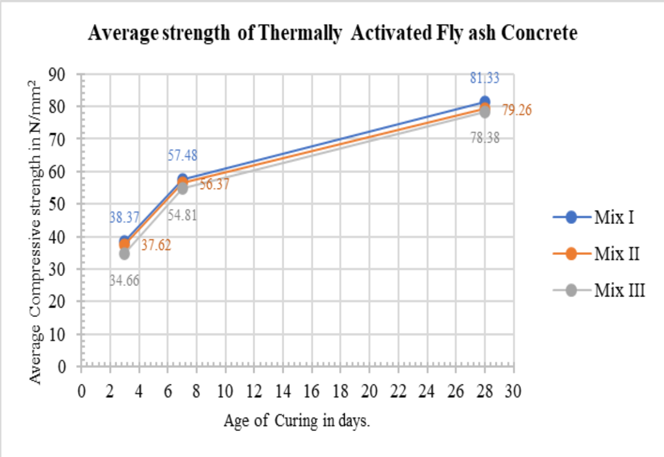

Chart -2: Thermally activated fly ash mix results.

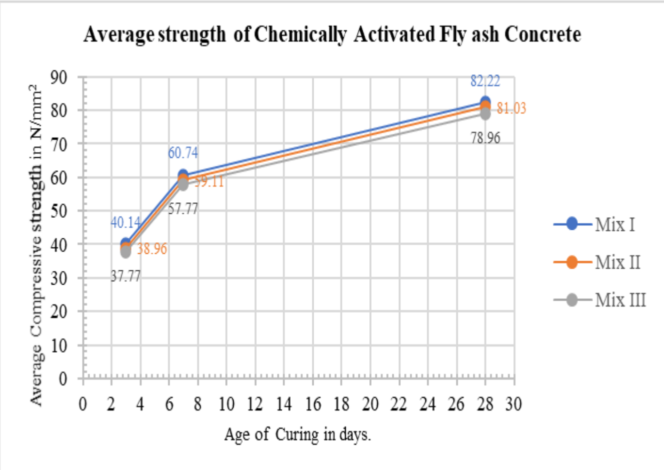

Chart -3: Chemically activated fly ash mix results.

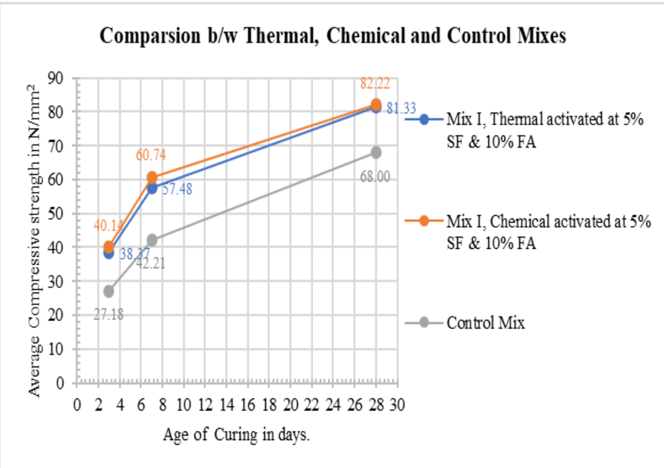

Chart -4: Mix I of Thermal & Chemical compared with Control mix

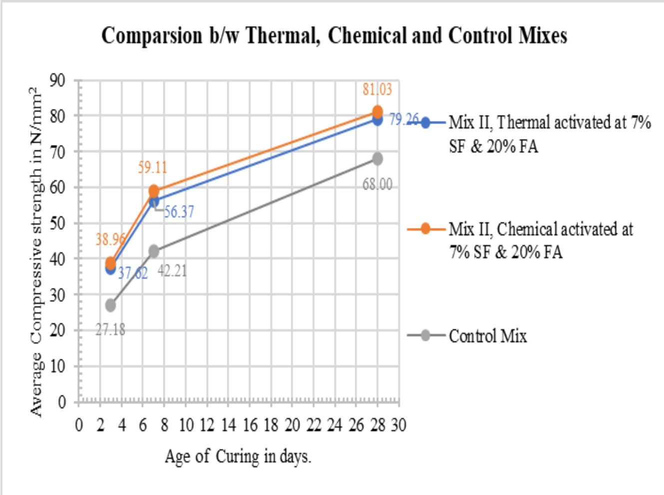

Chart -5: Mix II of Thermal & Chemical compared with Control mix

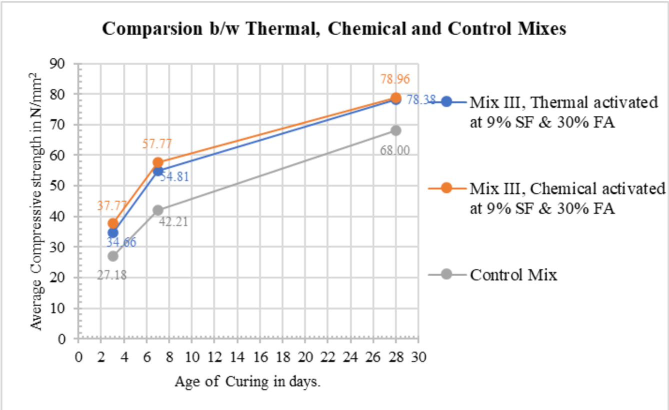

Chart -6: Mix III of Thermal & Chemical compared with Control mix

6. CONCLUSIONS

1. Workability of all three mix i.e. M I, M II and M III maintained by the use of super plasticizers even for low water-cement ratio.
2. Introducing Silica fume and fly ash in concrete results in significant improvement in compressive strength.
3. The 3, 7- and 28-days compression strength of concrete mix with chemically activated fly ash is more than compare to the thermal activated fly ash.
4. The optimum 28-days compressive strength is obtained in the range of 5% silica fume and 10% fly ash.

REFERENCES

[1] S. Senthilkumar, K. Sekar and K. Perumal , “Expirimental Investigation on Strength Characteristics of High Performance Concrete using Silica fume and Superplasticizer,” International Journal of Trend in Scientific Research and Development, vol. 2, Oct. 2018. pp. 382-390.

[2] M. Philalay, N. Drahos and D. Thurtell, "Coal in India", Australia, 2019.

[3] A. Shyam, A. Anwar and S. A. Ahmad, "A Literature Review on Study of Silica fume as Partial Replacemnet of Cement in Concrete," International Journal of Advance Engineering, Management and Science, vol. 3, March 2017, pp. 250-253.