International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 | Aug 2020 www.irjet.net p-ISSN: 2395-0072

Experiment on Strength Properties of High Performance Concrete with the Incorporation of Activated Fly Ash

Rohini Devoor[1], Chaitra D M[2], Yashwanth N[3]

[1]M. Tech Student, Dept. of Structural Engineering, NCET, Bengaluru
Assistant Professor, Dept. of Civil Engineering, NCET, Bengaluru
[3]M. Tech Student, Dept. of Structural Engineering, NCET, Bengaluru

---

Abstract - *Every year more than 90 million tons of fly ash is produced in India. Out of which only 10 to 15% is being utilized. In order to increase its percentage of utilization, an extensive investigation was carried out to use it in concrete. Fly ash is an ultrafine powder which is collected as a by-product of the silicon and ferrosilicon alloy production. Activation of fly ash is done by two ways, i.e. chemical activation and thermal activation. The main objective of this study was to determine the optimum percentage dosage of activated fly ash to replace cement in order to improve the strength properties of high performance concrete. This paper presents the results of an experimental investigation dealing with concrete with incorporation of activated fly ash. Ordinary Portland Cement was replaced with three percentages i.e., 10%, 20% and 30% of activated fly ash. To fulfill this objective comparison between conventional concrete and high-performance concrete containing different levels of activated fly ash like 10%, 20% and 30% content was conducted. Various tests were performed to check the properties of fresh concrete for such as slump test, air content, compressive test, split tensile test. The test results were studied to find the optimum dosage of activated fly ash required in concrete and found out that the chemically activated fly ash concrete mix achieves higher strength when compared to thermally activated fly ash.*

Key Words: **Activation, Chemical, Thermal, Fly ash, Strength**

1. INTRODUCTION

Cement is the most cost and energy efficient component of concrete. The unit cost of concrete can be reduced by replacing partially of cement with activated fly ash. Fly ash is the by-product of the combustion of silicon and ferrosilicon alloy are collected by mechanical and electrostatic separators from the fuel gases of power plants. The disposal of fly ash as a waste material causes severe hazardous issues for environment. The utilization of fly ash instead of dumping it as a waste material can be partly used as partial replacement of cement. Fly ash has several benefits to be considered in construction field such as lower water demand, reduced bleeding and lower evolution of heat. It is been used widely in large concrete applications to control expansion due to heat of hydration and also to reduce cracking at early stages. High volume fly ash concrete usually contains more than 50% fly ash by mass of total cementitious materials. Many inventors have used high volumes of Class C and Class F fly ash in concrete [1].

Researchers have found that Fly ash is one of the best pozzolanic material which when replaced in partial of cement improves durability and long term strength due to presence of fine spherical shape particles. And noticed that 15 to 25% of Fly ash replacement have good effect on the tensile strength of concrete. They have also indicated that though the initial strength of Fly ash concrete may be low, with age the strength is comparable for better compressive strength, heat of hydration and chloride diffusivity of concrete [2].

There are several ways by which activation of Fly ash can be done. Numerous investigators have performed chemical activation process to activate fly ash. Another common method used by investigator to improve early age strengths is the use of chemical admixture. Many commonly available admixtures have the property to accelerate the hydration of concrete, which reduces water and super plasticizer at the same time. The reduction of water in the concrete due to the addition of super plasticizer helps in improving the strength. The chemical activators used are sodium sulphate, calcium sulphate and sodium hydroxide [3].

Fly ash has exhibited several advantages which can be used in construction site. It has several properties like cold weather resistance, gaining higher strength, used as an admixture, as substitution for cement, as a non-shrink material, produces denser concrete, smoother surface, lower water/cement ratio, reduces cracking in concrete, permeability, bleeding and reduces heat of hydration. In geotechnical industry fly ash is involved in several applications such as in brick material, soil stabilization, fillings for embankment, backfill material, sub base and pavement construction [4]. The following article deals with various activation techniques to accelerate the reactivity of Fly ash in concrete. Latterly a comparative assessment of these methods by considering the compressive strength of concrete.

2. ACTIVATION OF FLY ASH

The method of enhancing activity of pozzolanic materials in concrete in order to improve the hydration capacity of concrete. There are several ways in which activation can be done. A brief review of chemical activation and thermal activation technique is presented below.

2.1 Chemical Activation

Various researches have been carried out using chemical activators in order to accelerate the hydration process of Fly ash combined with cement and thereby improving the strength of the concrete. Chemical activation are of various types depending upon the chemicals used such as Alkali activation, sulphate activation, activation by high molecular materials, composite activator.

2.2 Thermal Activation

Physio-chemical activation is the method in which both physical and chemical activation of Fly ash is done. This activation method is further sub divided such as Low temperature calcination, thermal activation, hydro thermal activation.

Thermal activation: In this activation process, the blending of the pulverized fuel ash and pulverized lime in certain proportion is put in an autoclave for some appropriate time and at appropriate temperature followed by dehydration and cooling. This technique deals with large investment and complicated techniques as the autoclave is used. Some researchers adopted this technique of activation of fly ash blended cement to improve the strength and also the corrosion resistance of concrete. They reported that around 20-30% of activated fly ash can be easily replaced with cement to achieve high strength.

3. SUPPLEMENTARY MATERIAL OF CEMENT

3.1 Fly ash

Several power stations use coal like fuel as worldwide energy sources and consequently high volume of fly ash is being produced now the days. Consequently only a small part of this ash is been utilized contributing to only about 15-20%. Fly Ash, a siliceous material is the coal produced combustion product, composed of the fine particles that are driven out of the boiler with the flue gases. The bottom ash is the ash that settles down in the bottom of the boiler. The Fly ash obtained from different thermal power stations is considered as cementitious/supplementary material of cement. The recycling of fly ash has been an increasing concern in recentage due to increasing landfill costs and recent issues related to sustainable development. The use of fly ash in replacing a portion of the cement has resulted in significant benefits in the cost of production of concrete. It was also found that, in order to get similar properties as that of Ordinary Portland cement (OPC), fly ash require special treatment techniques like chemical activation, thermal activation, alkali activation, mechanical grinding.

Table -1: Mix Design Proportions

Mix	Mix I	Mix II	Mix III
Materials (Unit)	**10% FA**	**20% FA**	**30% FA**
Cement (kg/m³)	520.48	462.66	402.84
Water (kg/m³)	188	188	188
FA (kg/m³)	788.24	817.04	845.70
CA (kg/m³)	919.24	952.64	986.04
W/C	0.325	0.325	0.325
Fly Ash (kg/m³)	57.82	115.64	173.46

FA-Fine aggregate, CA-Coarse aggregate and W/C-Water Cement ratio

4. METHODOLOGY

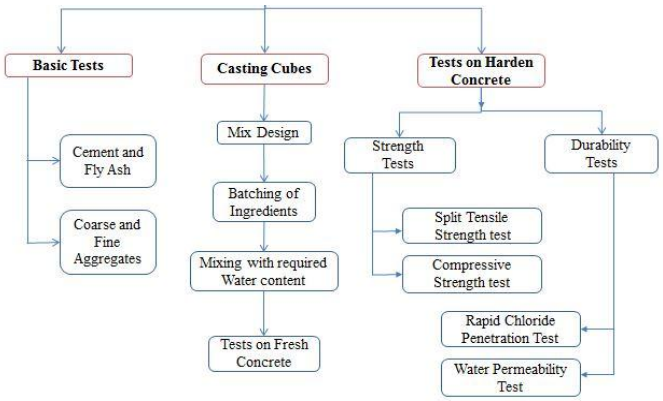

Chart -1: Methodology

5. EXPERIMENTAL RESULTS

Comparison between thermally and chemically activated fly ash concrete has been made. It is represented by plotting a graph as in x-axis Age of curing in days and in y-axis Average Compressive strength in N/mm². Different percentages of Fly ash i.e., 10%, 20% and 30% in concrete which was activated chemically and thermally is compared with conventional concrete. The results of the test are graphically represented below.

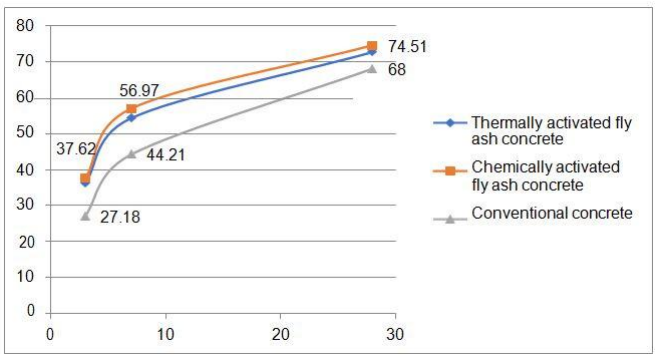

Chart -2: Test results of thermally and chemically activated (10%) fly ash concrete and conventional concrete

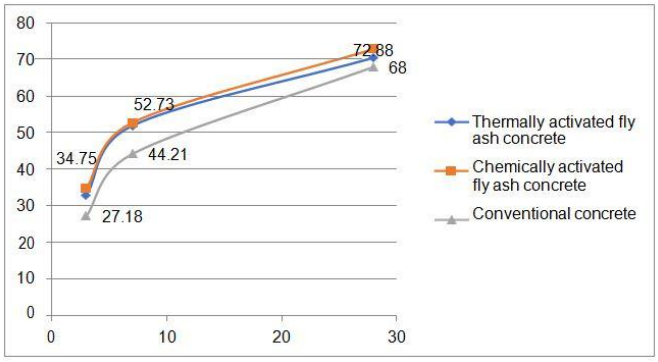

Chart -3: Test results of thermally and chemically activated (20%) fly ash concrete and conventional concrete

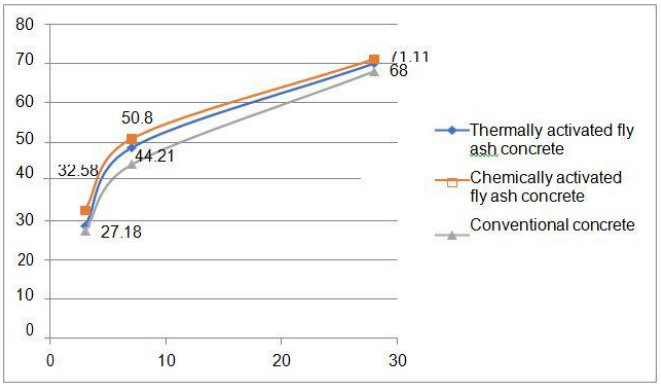

Chart -4: Test results of thermally and chemically activated (30%) fly ash concrete and conventional concrete

6. CONCLUSIONS

1. Activated fly ash helps in development of improved strength and corrosion resistance building material.
2. Fly Large quantities of fly ash can be utilized in an economical and environmental friendly manner in some highly invested industries or projects. Fly ash can also be used for several geotechnical works.
3. The initial strength is extremely low and thus cannot be considered as the best one. Chemical activation technique is preferred by most of the researchers.
4. Activation techniques are not preferred for mass production since additional chemical and mechanical processing costs counteract the economic aspects as compared to cement replacement cost in concrete.
5. When compared to chemically activated fly ash concrete, the thermally activated fly ash concrete shows less compressive strength for 3, 7 and 28 days.
6. Among the activated systems, chemically activated Fly ash developed the corrosion resistance as well as strength of concrete to a higher extent
7. Activated Fly ash act as both setting and hardening accelerator.

REFERENCES

[1] Rafat Siddique, "Performance characteristics of high-volume Class F fly ash concrete," Thapar Institute of Engineering and Technology, Deemed University, Patiala, PunjaB 147 004, India Received 18 March 2003; accepted 4 September 2003-Cement and Concrete Research 34 (2004) 487 – 493.

[2] Sanjukta Sahoo, "A Review of Activation Methods in Fly Ash and the Comparison in Context of Concrete Strength", Journal of Basic and Applied Engineering Research, Bhubaneshwar Volume 3, Issue 10; July-September, 2016, pp. 883-887.

[3] K. J. Owens, Y. Bai, D. Cleland, P.A.M. Basheer, J. Kwasny, M. Sonebi, S. Taylor and A. Gupta, "Activation of High Volume Fly Ash Pastes Using Chemical Activators", Second International Conference on Sustainable Construction Materials and Technologies June 28 - June 30, 2010.

[4] Sreelakshmi Dinesh, Annie Joy, "Alkaline Activation of Fly Ash: An Overview", International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 11 Nov 2018 p-ISSN: 2395-0072.