|| Volume 5 ||Issue10 || October 2020 ||ISSN (Online) 2456-0774
INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH AND ENGINEERING TRENDS

FLY ASH BASED GEO-POLYMER CONCRETE

Nayan U Deshpande[1], Hrithik K Chavhan[2], Prajwal P Lokhande[3], Girdhar Shendre[4]

Bachelor of Engineering, Civil & Mechanical Engineering, Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, Maharashtra, India [1 2 3 4]

nayandeshpande76@gmail.com[1], hrithik123chavhan@gmail.com[2], prajwallokhande2@gmail.com[3]

krishna06022000@gmail.com[4]

-- ***--

Abstract: - To decrease greenhouse gas emissions, there is a need to develop environmentally friendly material for infrastructure development. This paper presents the experimental procedure of fly ash based geo-polymer concrete. Geo-polymer is a superior material and is a by-product of material rich in silicon and aluminum, such as low calcium fly ash, is chemically activated by a high-alkaline solution to form a paste that binds the coarse and fine aggregates and other materials in the mixture which owns a good binding property. In last few years, lots of research works have been carried out globally to examine the various engineering properties of geo-polymer concrete as a sustainable alternative construction material to Ordinary Portland Cement. Currently, high-strength and high grade concrete is mostly used in most of the important civil construction works, such as high-rise buildings, skyscrapers and bridges because of its structural and economical benefits over Ordinary Portland Cement (OPC) concrete. This paper shows the effects of various parameters on the properties of geo-polymer concrete, and also shows the both economical benefits and contribution of geo-polymer concrete in sustainable infrastructure development.

Keywords: - *Geo-Polymer, High Strength Concrete, Fly Ash Compressive Strength*

--- ***--

I INTRODUCTION

Globally, the involvement of Ordinary Portland Cement (OPC) for the production of greenhouse gas emissions is estimated to be around 1.95 billion tons annually or roughly 8.5% of the total greenhouse gas emissions to the earth' s atmosphere. As per the report from concrete industry, many concrete structures, particularly those built in mordant environments, will start to deteriorate after 20 to 30 years, even though they have been designed for more than 45 years of service life. In this paper, strategies for both to create a concrete an environmentally friendly material for the future and also to retain concrete for an infrastructure development, have been outlined. The long-term goal of reducing the impact of unnecessary by-products of industry can be attained by lowering the rate of material consumption. It is needed to partially replace the amount of OPC in concrete with the by-product of burning pulverized coal called fly ash to make the concrete more environmentally friendly. An important achievement in this regard is the development of high-volume fly ash (HVFA) concrete that uses around 40% of OPC, and yet possesses admirable mechanical properties with superior durability performance. The development of inorganic alumina-silicate polymer which is also known as geo-polymer is synthesized from the by-product of materials such as fly ash that are rich in silicon and aluminum. Instead of the cement paste, the geo-polymer paste can be used as a binder to produce concrete. Fly ash is one which is available abundantly worldwide and can be used as a source material for geo-polymer binders. Especially in countries such as China and India, in future, fly ash production will increase. From these two countries alone, it is estimated that by the year 2030 the amount of the fly ash produced will be 1580 million tonnes annually. To make concrete more environmentally friendly, use of this by product material in concrete manufacture is significant. This paper presents the process of making geo-polymer concrete using low-calcium dry fly ash as its source material, and effect of some parameters on geo-polymer concrete with some economical benefits.

II WHAT IS GEO-POLYMER CONCRETE

Geo-polymer is an inorganic polymer, made with the combine reaction of alkali solution and alumina-silicate compounds. High-strength geo-polymer concrete can be created with a very simple mix design. High-strength concrete offers a lot of advantages over normal strength concrete, such as gaining higher strength at early days and higher mechanical strengths at later age.

Figure 1 Fly ash based Geo-Polymer Concrete

It also has lower permeability and great durability. Because of these advantages bigger volume of concrete can be replace by a slim section of high-strength concrete, thus it reduces structural self-load, construction cost and also the duration of construction. High-strength geo-polymer concrete offers a lot of advantages over conventional OPC based high-strength concrete, such as higher mechanical strengths, lower shrinkage and superior durability with environmental sustainability.

III EXPERIMENTAL PROCEDURE

In this process, the fly-ash & aggregate is mixed for 3 to 4 minute such that the proper mixture can be developed. The high range water reducing mixture as well as alkaline solution which generally mix-up together, then that mixture is then add together in solid box again for 4 to 5 minute .The mixture which is developed is the add to the mould of size 100x200mm. Every layer gives tamping of 20 and gives vibration up to 15 seconds. 5 cylindrical moulds can be used for a test. Suddenly after casting it is then covered with thin film such to avoid the evaporation of water. Again after curing it is again placed in room temperature for 30 to 50 minute. At last the mould of 100x200mm is then placed in the plastic such for 7 hours to avoid sudden changes in it.

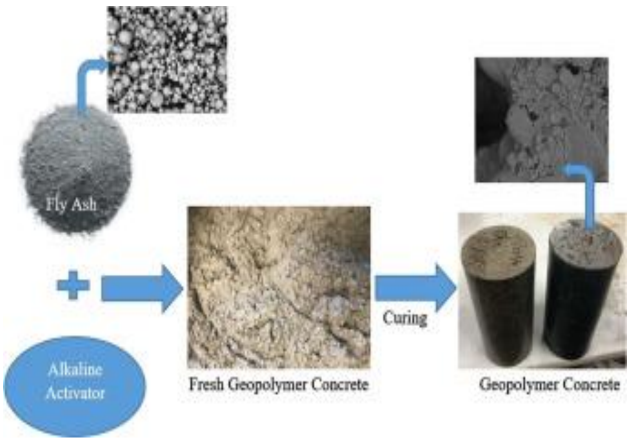

Figure 2 Preparation of Geo-Polymer Concrete

Then that specimen is then placed in dry air when the compression test is being test on UTM I.e. Universal Testing Machine. The specimens were weighed to find out the density of the material, before testing. The test procedures and the other loading rate were used, according to the details specified for testing OPC concrete, in relevant standards.

IV EFFECTS OF VARIOUS PARAMETERS

In this section, we have directly concluded the influence of various parameters on the compressive strength of geo-polymer concrete as observed in the laboratory tests.

A. Concentration of Sodium Hydroxide

Higher the presence of sodium hydroxide solution in a geo-polymer concrete results in a higher compressive strength of geo-polymer concrete.

B. Curing Temperature

As the curing temperature increases from 27 to 90 °C, the compressive strength of geo-polymer concrete also increases.

C. Curing Time

Longer curing time produces larger compressive strength of geo-polymer concrete (In the range of 7 to 96 hrs). But, the increase in strength beyond 48 hrs is not important.

D. High Range Water Reducing Mixture

The addition of approximately 2% of fly ash (By mass), enhances the workability of fresh geo-polymer concrete with a slight effect on the compressive strength of hardened concrete.

E. Water Content

As the ratio of water content increases, the compressive strength of the concrete decreases.

F. Handling Time

Without any difficulty we can easily handle the fresh geo-polymer concrete up to 120 min with no sign of setting and without any degradation in the compressive strength.

G. Age of Concrete

The compressive strength of geo-polymer concrete cured for 24 hrs at 60 °C does not depend on the age and the geo-polymer concrete undergoes very less creep and shrinkage. Against sodium sulphate, the resistance of geo-polymer concrete is admirable.

H.Unit Weight

The unit weight of concrete mainly depends upon the unit weight of aggregates used in the mixture. The unit weight of the concrete varied slightly between 2330 to 2430 kg/m3.

Type of Curing	Ultimate Load (N)		Compressive Strength (N/mm²)			
	7 Days	28 Days	7 Days	Avg.	28 Days	Av
Ambient Curing	9000	40400	3.92	3.89	17.614	17.6
	9200	39800	4.01		17.353	
	8550	41200	3.73		17.963	
Hot Oven Curing	67600	81000	29.47	28.31	35.316	33.2
	53000	69000	23.11		30.084	
	74200	78600	32.35		34.269	

Figure 3 Compressive Strength Chart of Geo-polymer Concrete

V CONTRIBUTION OF GEO-POLYMER CONCRETE TOWARDS SUSTAINABLE DEVELOPMENT

Coal is often used in the generation of the power in many countries of the world such as India, China, Australia and the USA. Globally, huge amount of superior quality coal is available and the low cost of power generated from these resources cannot be unnoticed or ignored. Coal burning power stations generate high amount of fly ash; most of the fly ash is inefficiently used. If we rely on coal fired power generation, the volume of fly ash would increase, as the need for power increases. On the other hand, infrastructure developments are increasing nowadays and hence concrete usage around the globe is also increasing. Ordinary Portland Cement is an important ingredient in the conventional concrete. The production of one tonne of cement emits roughly one ton of carbon dioxide to the atmosphere.

For sustainable development, an alternative binder to the Portland cement is a need for the concrete industries .Such an alternative is obtainable by the fly ash-based geo-polymer concrete, as this concrete does not use Portland cement; instead it utilizes the fly ash from coal-burning power stations to make the binder essential to manufacture concrete. The use of fly ash-based Geo-polymer Concrete contributes through the process of Carbon Reduction Scheme (CRS) between the Power Generators, Coal Producers, the Government Agencies, and other industries including the cement producers.

VI ECONOMIC BENEFITS OF GEOPOLYMER CONCRETE

Low-calcium fly ash-based geo-polymer concrete offers many economical benefits over Ordinary Portland Cement (OPC) concrete. The price of one tonne of fly ash is only a small fraction of the price of one ton of Portland cement. As a result, the cost of Ordinary Portland Cement (OPC) concrete becomes costlier than that of fly ash-based geo-polymer concrete. Additionally, one tonne of fly ash earns roughly one carbon credit by its appropriate use that has a major liberation value. One tonne low-calcium fly ash can be utilized to manufacture around 2 to 3 cu.m of high class fly ash-based geo-polymer concrete, and hence earn economical benefits through carbon credit trade. In addition, the very little drying shrinkage, the low creep, the excellent resistance to sulphate attack, and good acid resistance offered by the heat-cured low-calcium fly ash based geo-polymer concrete may yield additional economic benefits when it is used in the application of infrastructure.

VII CONCLUSION

The paper deals with the brief details of fly ash-based geo-polymer concrete. An easy process to design geo-polymer concrete mixtures has been illustrated and described. High-strength geo-polymer concrete offers numerous advantages over conventional OPC based high-strength concrete, such as higher mechanical strengths, lower shrinkage and superior durability with environmental sustainability. Due to higher tensile and flexural strength, this concrete will be more useful in high-rise buildings, skyscrapers and bridge structures where flexural strength is more essential. In high-strength concrete, it eliminates the issue of high heat of hydration in early age. High-strength geo-polymer concrete does not need any chemical admixtures to attain sufficient workability level, which facilitates an easier mixing process.

Geo-polymer concrete requires 20-25% less binder than conventional concrete of comparable characteristic strength. This different factor makes the high-strength geo-polymer concrete as an economical constructional material. Limited studies have been conducted on the long-term and durability performance of geo-polymer concrete. The results shows that the geo-polymer concrete had good resistance against shrinkage and better performance against the sulfuric acid and magnesium sulfate solutions when compared to concrete with OPC.

The chemical admixtures which are commercially obtainable are efficient in OPC based concrete, but cannot be used efficiently to modify the properties of fresh geo-polymer concrete. This can bound the commercial application of high-strength geo-polymer concrete. Further more research analysis and development of chemical admixtures which might be applicable in geo-polymer concrete is required.

REFERENCES

[1] Ryu, G. S., et al., The mechanical properties of fly ash-based geo-polymer concrete with alkaline activators. Construction and Building Materials, 2013

[2] Bashir, I., K. Kapoor, and H. Sood, An International Journal of Research in Science and Technology, 2017

[3] Rangan, B. V., " Mix design and production of fly ash base geo-polymer concrete" , Indian Concrete Journal.

[4] D. and Rangan, B. V., " Development and Properties of Low Calcium Fly Ash Based Geo-polymer Concrete" , Research Report GC1, Faculty of Engineering, Curtin University of Technology.

[5]S. E. and Rangan, B.V., " Low Calcium Fly Ash Based Geo-polymer Concrete: Long Term Properties." Research Report GC2, Faculty of Engineering, Curtin University of Technology.