IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 5, Oct-Nov, 2014
ISSN: 2320 – 8791 (Impact Factor: 1.479)
www.ijreat.org

Review on Effects of Different Supplementary Materials in Geopolymer Concrete

Yagnesh Patel[1], Indrajit Patel[2], Jagruti Shah[3]

[1] M.E Structure, BVM Engineering College,
V.V Nagar, Gujarat-388120, India

[2]Professor, Structural Engineering Department, BVM Engineering College,
V.V Nagar, Gujarat-388120, India

[3]Project Coordinator, Gujarat Technological University,
Ahmedabad, Gujarat-382424, India

Abstract

Concrete is the most abundant manmade material in the world. Concrete usage around the world is second only to water. One of the main ingredients in a normal concrete mixture is Portland cement. Ordinary Portland Cement (OPC) is conventionally used as the primary binder to produce concrete. However, cement is responsible for approximately 7% of the world's carbon dioxide (CO_2) emissions. Reduction of cement usage will reduce the production of cement which in turn cut the CO_2 emissions. As per the report, unmindful pumping of CO_2 into the atmosphere is the main culprit for the climate change. From theoretical consideration, it is observed that Geopolymer concrete is sustainable solution for construction and to improve properties like durability and workability of concrete. Geopolymer concrete uses fly ash, a byproduct created from the burning of coal. The present paper is discussing brief review on effects of different supplementary materials incorporating with Geopolymer concrete.

Keywords: *Carbon Dioxide (CO_2), Fly Ash, Geopolymer Concrete, Ordinary Portland cement (OPC).*

1. Introduction

Concrete is the world's most versatile, durable and reliable construction material. Next to water, concrete is the most used material, which required large quantities of Portland cement. OPC production is the second only to the automobile as the major generator of CO_2, which polluted the atmosphere. In addition to that large amount energy was also consumed for the cement production. Hence, it is inevitable to find an alternative material to the existing most expensive, most resource consuming Portland cement. Geopolymer concrete is an innovative construction material which shall be produced by the chemical action of inorganic molecules. Fly Ash, a by- product of coal obtained from the thermal power plant is plenty available worldwide. Fly ash is rich in silica and alumina reacted with alkaline solution produced alumino silicate gel that acted as the binding material for the concrete. It is an excellent alternative construction material to the existing plain cement concrete. Geopolymer concrete shall be produced without using any amount of ordinary Portland cement.

The use of Geopolymer concrete in construction is a solution to environmental degradation being caused by cement industry. OPC is widely used in India due to its low cost and easy availability. As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. On the other hand it also affects environment. There many negative impact of OPC. For example emissions of airborne pollution in the form of dust, gases, noise, and vibration when operating machinery and during blasting in quarries, consumption of large quantities of fuel during manufacture, release of CO_2 from the raw materials during manufacture. Due to all such various reasons it is needed to be replaced by non producing CO2 materials such as fly ash and various supplementary materials. Geopolymer concrete replaces OPC fully.

Geopolymer concrete does not use Portland cement; it uses a highly abundant material called fly ash. Fly ash is a waste product, so Geopolymer concrete is actually recycling product when it is created. It is also more resistant to salts, acids, seawater corrosion, and fire. Geopolymer concrete is also much more durable that ordinary concrete due to its resistance to corrosion. It is also much stronger than ordinary concrete. Geopolymer concrete is a high strength and lightweight inorganic polymer that can be used in place of normal concrete. The main difference between normal concrete and Geopolymer concrete is that normal concrete used OPC as a binder whereas Geopolymer

concrete uses a chemical and fly ash mixture as a binder. Geopolymer concrete has multiple benefits; unfortunately, it has seen very little application in the construction industry so far.

2. Objective

The main objective is to review the effects of supplementary materials on different engineering properties incorporating with Geopolymer concrete.

3. Literature review

Gaurang D. Bhavsar, Kinjal R. Talavia, Dhruv P. Sutharv Manali B. Amin, Abhijitsinh A. Parmar[1] conducted study on workability properties of Geopolymer concrete using accelerator and silica fume as an admixture. From the slump test the result indicate that the increase in proportion of silica fume, it gives a less workability, more workability can achieve by increase in proportion of plasticizer and the effect of accelerator the Geopolymer concrete setting time decreased so concrete slump will be minimum and the workability will become less.

Sundar Kumar, S, Vasugi, J., Ambily, P. S. and Bharatkumar, B. H[2] studied the of mechanical properties such as compressive strength, split tensile strength and flexural strength of fly ash and slag based Geopolymer concrete and the result was compared with an OPC based concrete. It can be seen that both OPC and GPC mixes were able to achieve a 28 days compressive strength in excess of 50 MPa through OPC mixed had a slightly more strength. The split tensile strength was enhanced by 1.26 times and the flexural strength by 1.37 times.

D B Raijiwala, H S Patil, I U Kundan[3] studied the influence of alkaline activator on the strength and durability properties of Geopolymer concrete which include compressive strength, tensile strength, split tensile strength. Sodium hydroxide and Potassium hydroxide were added by the same amount (50% NaOH+50%KOH) as alkaline activators along with sodium silicate at varying temperature. The results indicate that the combination of the above constituents at 80°C has a positive impact on the strength and durability properties of Geopolymer concrete. Thet noticed that the Compressive strength of GPC increased over controlled concrete by 1.5 times (M-25 achieves M-45), Split Tensile Strength of GPC increased over controlled concrete by 1.45 times and Flexural Strength of GPC increased over controlled concrete by 1.6 times.

Sourav Kr. Das, Amarendra Kr. Mohapatra and A.K. Rath[4] reviewed on various parameters which affect the properties of Geopolymer concrete such as ratios of SiO_2/Na_2O, fineness of fly ash, molarity, curing, fly ash and alkaline activator ratio. The study shows that higher the fineness of fly ash gives a higher compressive strength. With a higher Na_2O/SiO_2 gives a higher strength. Generally heat cured Geopolymer concrete gives higher strength. It was observed that higher fly ash content with a higher alkaline activator content gives a high compressive strength as in figure 1.

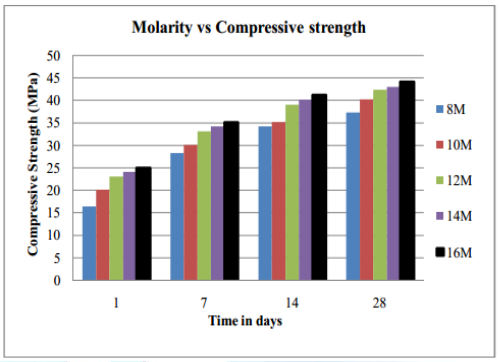
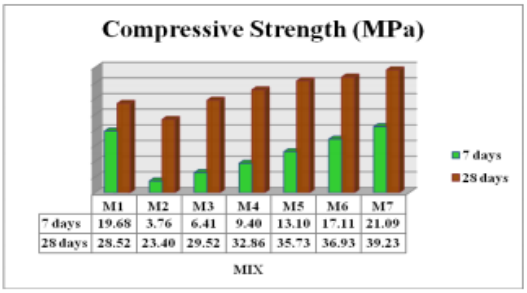


Fig. 1 Molarity Vs. Compressive Strength

A.R.Krishnaraja, N.P.Sathishkumar, T.Sathish Kumar, P.Dinesh Kumar[5] studied mechanical behavior of Geopolymer concrete under ambient curing and checked the various strength of various mixes. Due to the constant increase in the percentage of slag content there was a constant increase in compressive strength was observed. Compressive strength of Mix M7 (50% replacement of slag) concrete shows better result than conventional concrete and other mixes as presented in figure 2. and also split tensile strength of mix M7 (50% replacement of slag) concrete given better result when compared with all the mixes as shown in figure 3. Based on the study carried out, replacement of Grand Granulated Blast-Furnase Slag (GGBFS) in fly ash up to 50% produced better mechanical properties.



	M1	M2	M3	M4	M5	M6	M7
7 days	19.68	3.76	6.41	9.40	13.10	17.11	21.09
28 days	28.52	23.40	29.52	32.86	35.73	36.93	39.23

Fig. 2 Compressive strength of various mixes.

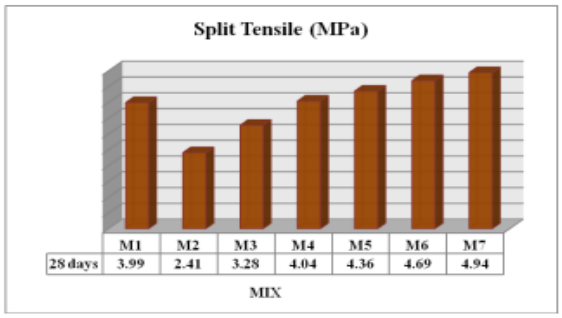


Fig. 3 Split tensile strength for various mixes

Mohd Mustafa Al Bakri, H. Mohammed, H. Kamarudin, I. Khairul Niza and Y. Zarina[6] reviewed on fly ash based Geopolymer concrete which include compressive strength. The compressive strength was increased when the finest of fly ash increase. The highest compressive strength was obtained using a solution of sodium silicateas an activator (n = 1.5; 10% Na_2O). It was also found that the fly ash-based Geopolymer displayed increase in strength after temperature exposure. Fly ash-based Geopolymer had been proved by many studies to provide better resistance against aggressive environment. The exposure of Geopolymer in acid solution shows that the weight loss due to the exposure is only 0.5% compared to normal concrete when immersed in 3% acid sulfuric (Sathia et al., 2008). As a conclusion, Fly ash-based Geopolymer is better than normal concrete in many aspects such as compressive strength, exposure to aggressive environment, and exposure to high temperature.

M.A.Bhosale, N.N.Shinde[7] investigated the study of the processing of Geopolymer using fly ash and alkaline activator with Geopolymerization process which include compressive strength. In this study, the mechanism of activation of a fly ash (no other solid material was used) with highly alkaline solution is described. These solution comprises the comparision of the ratios of Na2SiO3&NaOH at values 0.39&2.51. The factors that influence the early age compressive strength such as molarities of sodium hydroxide (NaOH) have been studied. The result showed that the Geopolymer paste with NaOH concentration, compressive strength increase with molarities increases.

4. Applications:

Geopolymer concrete is widely used for bridges, such as precast structural elements and deck as well as structural retrofits using Geopolymer-fiber composites. Geopolymer technology is most advanced in precast applications due to the relative ease in handling sensitive materials and the need for a controlled high temperature curing environment required for many current Geopolymers. Other potential near-term applications are precast pavers and slabs for paving, bricks and precast pipes. Few application of GPC is presented in fig 4 & 5.

Fig. 4 Ekka plaza, Brisbane, Sprig hill

Fig. 5 Brisbane west wellcamp airport pavement

5. Outcome

From the Literature review, the critical reviews are as follow:

- Geopolymer concrete use as an alternative of Portland cement and it reduce the CO2 emission in the world so it can be said that it helps to the nature that's why Geopolymer concrete represent as a "Green concrete" and also as an "Eco-friendly concrete".

- The experimental works prove that Geopolymer concrete with moderate to moderately high

strength can be developed at very low concentration of alkaline activator and ambient air curing.

- Use of fly ash in combination with slag is found to be more reactive and the strength gained is more.

- Specialized curing regimes such as stream curing, hot air curing are required only when accelerated strength gain is required. When the design strength is required only at 28 days normal air curing is sufficient.

- Higher the fineness of fly ash gives a higher compressive strength because of more surface area with more Si-Al bond for polymerization.

- Generally heat cured Geopolymer concrete gives higher strength but it can be obtained at ambient temperature by replacing fly ash content by GGBFS.

- Fly ash-based Geopolymer is better than normal concrete in many aspects such as compressive strength, exposure to aggressive environment, workability and exposure to high temperature.

6. Scope of the study

In this advanced technology era, Geopolymer concrete is widely used in the construction practice and can be an effective solution to replace OPC. Geopolymer concrete is a whole new concept of structural concrete with a new technology that is why Geopolymer concrete represent as a "Green concrete" and also as a "Eco-friendly concrete". For the modern application, I will be conducting my PG research for analyzing all the behavior and effects of NanoSilica incorporating with Geopolymer concrete.

References

[1] Gaurang D. Bhavsar, Kinjal R. Talavia, Dhruv P. Sutharv Manali B. Amin, Abhijitsinh A. Parmar, "Workability properties of Geopolymer concrete using accelerator and silica fume as an admixture". International Journal for Technological Research in Engineering volume 1, ISSN (Online): 2347 – 4718. 2014

[2] Sundar Kumar, S, Vasugi, J., Ambily, P. S. and Bharatkumar, B. H., "Developemnt and Determination of Mechanical properties of fly ash and slag blended Geopolymer concrete". International Journal of Scientific & Engineering Research, Volume 4, Issue 8, August 2013
ISSN 2229-5518

[3] D B Raijiwala, H S Patil, I U Kundan, " Effect of alkaline activator on the strength and durability of Geopolymer concrete" Journal of Engineering Research and Studies, JERS/Vol. III/ Issue I/January-March, 2012/18-21

[4] Sourav Kr. Das, Amarendra Kr. Mohapatra and A.K. Rath, "Geo-polymer Concrete – Green Concrete for the Future – A Review". International Journal of Civil Engineering Research.ISSN 2278-3652, Volume 5, Number 1 (2014), pp. 21-28

[5] A.R.Krishnaraja, N.P.Sathishkumar, T.Sathish Kumar, P.Dinesh Kumar, "Mechanical Behaviour of Geopolymer Concrete under Ambient Curing". International Journal of Scientific Engineering and Technology (ISSN: 2277-1581), Volume No.3, Issue No.2, pp: 130 – 132

[6] Mohd Mustafa Al Bakri, H. Mohammed, H. Kamarudin, I. Khairul Niza and Y. Zarina. "Review on fly ash-based Geopolymer concrete without Portland Cement", Journal of Engineering and Technology Research Vol. 3(1), pp. 1-4, January 2011

[7] M.A.Bhosale, N.N.Shinde. "Geopolymer concrete by using Fly Ash in construction", IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE), ISSN: 2278-1684 Volume 1, Issue 3 (July-August 2012), PP 25-30