ANALYSE THE EFFECT OF DIFFERENT FIBRES ON FLY-ASH BASED GEOPOLYMER CONCRETE

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ABSTRACT

In this work, low-calcium (Class F) fly ash-based geopolymer is used as the binder, instead of Portland or other hydraulic cement paste to produce concrete. The fly ash based geopolymer paste binds the loose coarse aggregates, fine aggregate sand other un-reacted materials together to form the geopolymer concrete.The main difference between class F Fly Ash (FFA) and class C Fly Ash (CFA) is the calcium content. The environment friendly alternative of the ordinary Portland cement is fly ash based geopolymer concrete The specimen were designed for the grade G30 with different types of fibre added to the concrete mix as 0.4%,0.8%,1.2%,1.6%,2.0%,2.4%,2.8%..Cubes were cast with different fibres for compressive strength.

The aim of this research paper is to compare the compressive strength and split tensile strength of different types of fibres with each other for same percentage of usage of fibre.

Keywords *:- Geopolymer concrete, Class F typed fly ash, Alkaline solution, Compressive Strength*

1.INTRODUCTION

Geopolymers are a relatively new group of materials which were developed by Joseph Davidovits in 1970's. Fly ash based geo polymer are one of the branch in the geo polymer family and these have attracted more attention since 1990's.The physical and chemical characteristics of fly ash mainly depend on coal source and method of production. Fly ash mainly contains the high percentage of silica and alumina. The main difference between class F Fly Ash (FFA) and class C Fly Ash (CFA) is the calcium content. Particle size, calcium content, alkali metal content, amorphous content, morphology and origin of fly ash may affect the properties of geo polymers. Calcium content in fly ash in significant quantities could interfere with polymerisation process. Utilisation of concrete as a major construction material is a worldwide phenomenon and the concrete industry is the largest user of natural resources in the world. Massive use of concrete is driving the massive global production of cement, estimated as about 2.8 billion tonnes. Associated with this is the inevitable carbon-di-oxide emission of about 7% of total global production. Geo Polymer Concrete is one of the green alternatives to Portland cement concrete.[3]

In this work, low-calcium (Class F) fly ash-based geopolymer is used as the binder, instead of Portland or other hydraulic cement paste to produce concrete. The fly ash based geopolymer paste binds the loose coarse aggregates, fine aggregate sand other un-reacted materials together to form the geopolymer concrete, with or without the presence of admixtures. The manufacture of geopolymer concrete is carried out using the usual concrete technology methods.The silicon and the aluminum in the low-calcium (ASTM Class F) fly ash react with an alkaline liquid that is a combination of sodium silicate and sodium hydroxide solutions to form the geopolymer paste that binds the aggregates and other un-reacted materials. In the present study, an experimental investigation on mechanical and elastic properties of low calcium fly ash based GPC has been carried out. Geopolymer concrete mixes were prepared with solution to fly ash ratio of 0.4.[5]

On the other side, fly ash is the waste material of coal based thermal power plant available abundantly but this poses disposal problem. Several hectares of valuable land are acquired by thermal power plants for the disposal of fly ash. With silicon and aluminium as the main constituents, fly ash has great potential as a cement replacing material in concrete. The concrete made with such industrial wastes is eco-friendly. Although the use of Portland cement is still unavoidable, many efforts are being made in order to reduce the use of Portland cement in concrete.

Several efforts are in progress to supplement the use of Portland cement in concrete in order to address the global warming issues. These include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin, and the development of alternative binders to Portland cement. Plain cement concrete suffers from numerous drawbacks such as low tensile strength, brittleness, unstable crack prop-agation, and low fracture resistance. Addition of fibres in plain cement concrete improves its mechanical and elastic properties. Hence, fibre reinforced concrete has been proved as a reliable and promising composite construction material having superior performance characteristics com-pared to conventional concrete.[1]

2. LITERATURE REVIEW

P.Eswaramoorthi,(2014)et.al[1] Researchers found out a useful method of replacing fly ash for cement in calculated qualities. Presently the percentage of replacement has been increasing. Here an experiment has been conducted to study the performance of concrete using fly ash as the major binding material without of cement. Low calcium fly ash is preferred as a source material than High calcium fly ash because of to reducing more carbon di oxide emission Alkaline liquid Sodium hydroxide and Sodium silicate solution are used in this project as binders. It is used in Geo polymerization process. Reactions occur at high rate when the alkaline liquid contains soluble silicate, either sodium or potassium silicate compared to the use of only alkaline hydroxides. A mix proportion for Geopolymer concrete was designed and carried out tests for different grade of concrete. The tensile strength and compressive strength of Geopolymer concrete have been studied and compared with OPC. Polypropylene is one of the cheapest & abundantly available polymers. Polypropylene fibers are resistant to most of the chemicals & it would be cementations matrix which would deteriorate first under aggressive chemical attack. Its melting point is high (about 165 degree centigrade).So that a working temp (about 100 degree centigrade).

A.Priyanka,(2017) et.al[2] have highlighted on the Influence of Steel Fibre in Geopolymer Concrete. Ordinary Portland Cement (OPC) production produces substaintial CO2 emission. which is a greenhouse gas causing global warming. To address the environmental constraints due to cement production, strength properties of high-calcium fly ash based geopolymer concrete (GPC) has been explored in this paper. For, Alkalineliquid combination, ratio of Sodium Silicate to Sodium Hydroxide solution was fixed as 2.5. Attention was paid upon the durability and flexural behaviour of steel fibre geopolymer concrete specimen. Cube, cylinder and prism were cast with and without fibreand cured in 10% concentration of sulphuric acid attack for the period of 28, 60 and 90 days for the strength and durability of concrete.

Atteshamuddin S. Sayyad,(2013) et.al[19] have studied the Effect of Steel Fibres and Low Calcium Fly Ash on Mechanical and Elastic Properties of Geopolymer Concrete Composites. Effect of steel fibres and low calcium fly ash on mechanical and elastic properties of geopolymer concrete composites (GPCC) has been presented. The study analyses the impact of steel fibres and low calcium fly ash on the compressive, flexural, split-tensile, and bond strengths of hardened GPCC. Geopolymer concrete mixes were prepared using low calcium fly ash and activated by alkaline solutions (NaOH and Na2SiO3) with solution to fly ash ratio of 0.35. Crimped steel fibres having aspect ratio of 50 with volume fraction of 0.0% to 0.5% at an interval of 0.1% by mass of normal geopolymer concrete are used. The entire tests were carried out according to test procedures given by the Indian standards wherever applicable. The inclusion of steel fibre showed the excellent improvement in the mechanical properties of fly ash based geopolymer concrete. Elastic properties of geopolymer concrete composites are also determined by various methods available in the literature and compared with each other.

Mr.Parag.S..Joshi,(2017)et.al[16] The worldwide production of Ordinary Portland cement is increasing at the rate of 9% annually and is contributing to the 5% to 8% of total emission of greenhouse gases. The environment friendly alternative of the ordinary Portland cement is fly ash based geopolymer concrete and is studied extensively. In this paper comparison of compressive strength between conventional concrete with different quantities of steel fiber and fly ash based geopolymer concrete with 8M and 16M and different quantities of steel fiber is done. The main aim of this paper is to compare the compressive strengths of conventional concrete reinforced with steel fiber and geopolymer concrete reinforced with steel fiber.

Behzad Nematollahi,(2014)et.al[4] evaluated the effects of glass fiber addition on the properties of fresh and hardened fly ash based geopolymer concrete (GPC) activated by 8 M NaOH solution (28.6%) + Na2SiO3 (71.4%) with a SiO2/Na2O ratio of 2.0. Glass fibers at the dosages of 0.50%, 0.75%, 1.00% and 1.25% by volume of concrete were added to the GPC mix. The properties of fresh and hardened glass fiber reinforced fly ash based

GPC in terms of workability, density, compressive and flexural strengths were compared with those of the fly ash based GPC without using glass fiber. The experimental results indicated that inclusion of the glass fibers resulted in decrease of the workability but increase of the density, compressive and flexural strengths of the fly ash based GPC with increased fiber content.

3. METHODOLOGY

3.1.SOURCE OF MATERIALS

FLY ASH :-

Fly ash is the waste material obtained as a residue from burning of a coal in furnace or locomotives. We get it in the powdered form. The colour of fly ash is either grey or blackish grey. It is one of the most abandoned material on earth. It is one of the main ingredients in creation of geopolymer concrete as it plays an important role in the geopolymerization process. There are two classes of fly ash class F and class C. Each class of fly ash has its own unique properties.

AGGREGATES:-

Locally available aggregates including coarse and fine aggregates, in saturated surface dry (SSD) conditions were used.

GLASS FIBER:-

The alkali-resistant glass fiber used in this study was in loose chopped strands form with 13 mm length, 0.014 mm nominal diameter and density of 2650 kg/m3 .The steel fiber used in geopolymer concrete has diameter 0.45mm, length of 25mm, it has aspect ratio of 55.55. Number of steel fibers per kg is 30946.

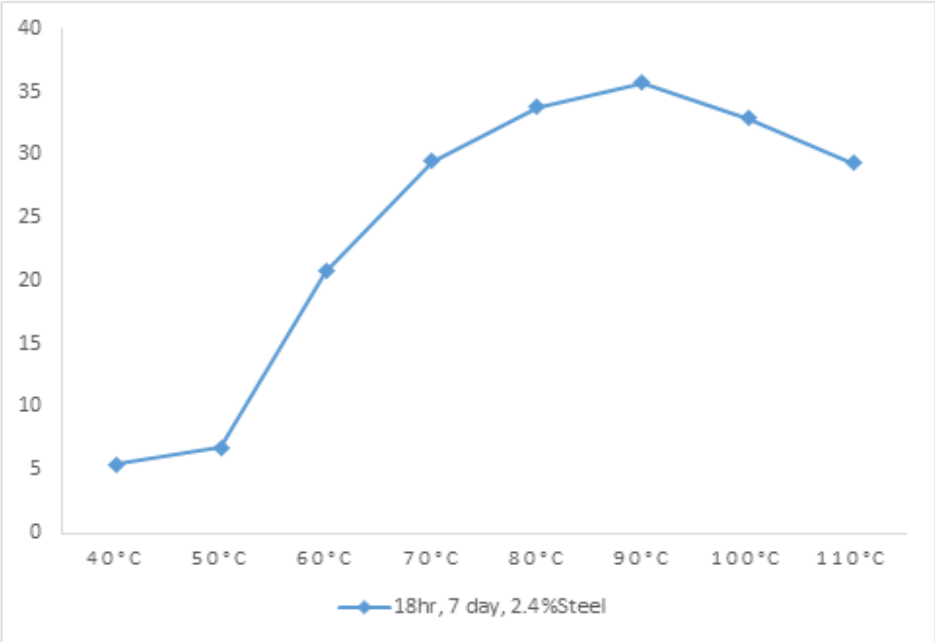
ALKALINE SOLUTION :-

The solution of sodium hydroxide and sodium silicate is used as alkaline solution in the present study. Commercial grade sodium hydroxide in pellets form (97%-100% purity) and sodium silicate solution having 7.5%-8.5% of Na2O, 25%-28% of SiO2, and water of 63.5%-67.5% are used.

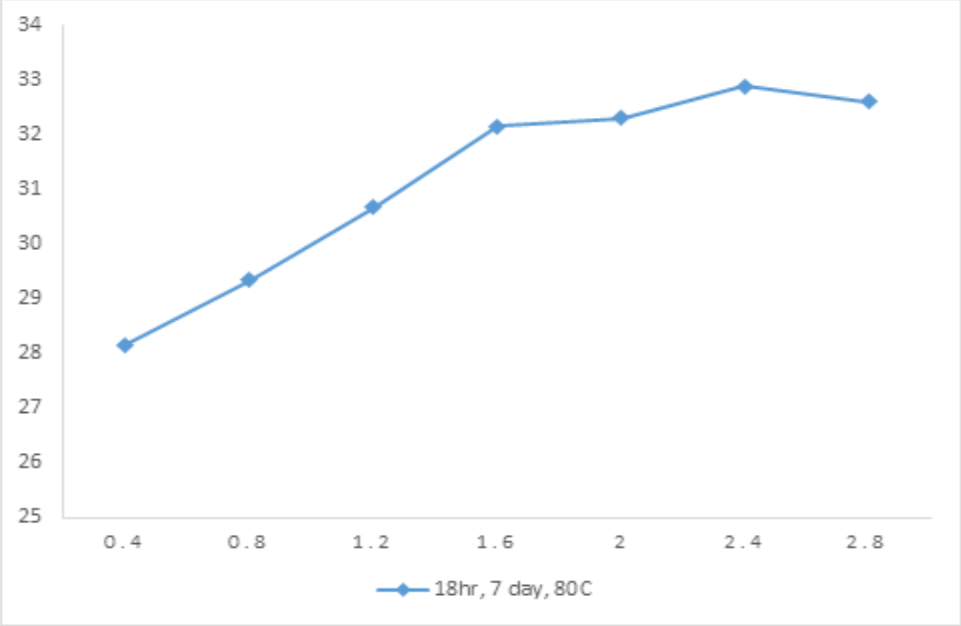
3.2.MIXING & CASTING DETAILS OF GPC

In this study 7 different mix designs was prepared to evaluate effects of the addition of different fibers on short term mechanical properties of fly ash based GPC by varying the fiber percentage from 0.4% to 2.8% by volume of concrete. The parameters investigated were workability of fresh concrete and density, compressive and flexural strengths of hardened concrete. In all of the mixes, the alkaline solution to fly ash ratio was kept constant equal to 0.4. The amount of water in the mixture played an important role on the behavior of fresh concrete. Mix sodium silicate solution and sodium hydroxide solution together prior to adding in the dry material.Mix all dry material in the pan mixer for about three minutes. Add the liquid component of the mixture at the dry mixing and continue the wet mixing for another four min component of the mixing at the end of dry mixing and continuous the wet mixing for another sometime.Add percentage of fibre in concrete gradually to ensure uniform fiber dispersion. To prepare the geopolymer concrete the fly ash and aggregates (comprising coarse and fine) were first dry mixed in a laboratory concrete pan mixer for 3min. The alkaline solution was then added into the mix and wet mixing continued for a further 4min. Subsequently, in the case of glass fibre reinforced geopolymer concrete, loose glass fibres were added in seven different proportions of 0.4%,0.8%,1.2%,1.6%,2%,2.4% and 2.8% by volume of concrete. Fibres were added gradually to ensure uniform fiber dispersion. The fresh concrete was then cast into standard 150×150×150 mm size cubes to measure the compressive and flexural strength of the hardened concrete, respectively. The concrete cubes were compacted by a table vibrator in 3 layers of equal height. For heat curing all the molds were sealed to minimize moisture loss and placed in the oven at 80° C for 24 hours. After 24 hours of heat curing the cubes are kept open in laboratory to ambient temperature for 7/28 days and then the tests on that cubes were carried out. Specimens are cast and demoulded then allowed to oven cure for 18hrs & then kept in ambient temperature for 7 days to rest cubes on plane surface, cylinders vertically in the upright longer side and the beams were laid in horizontal position.

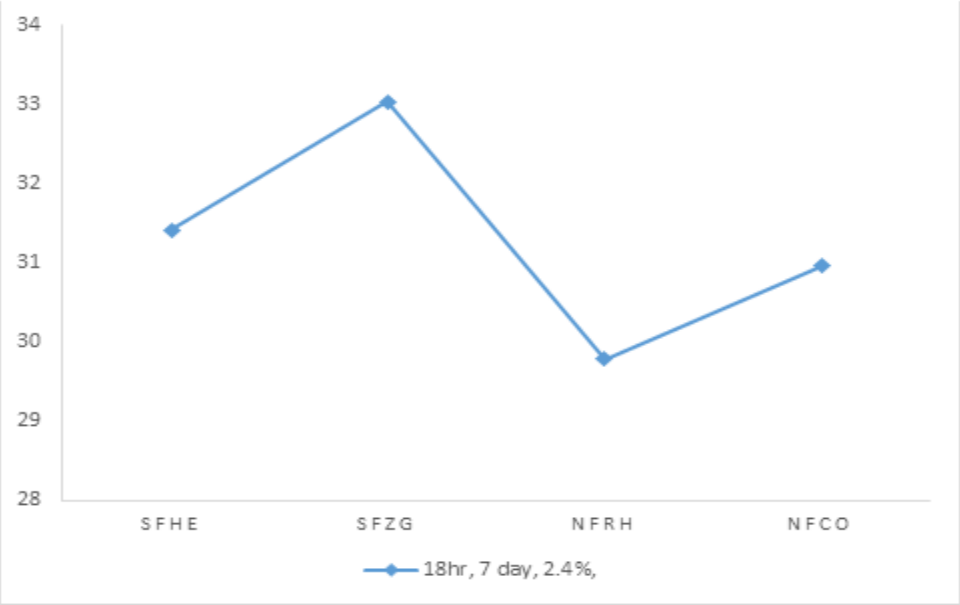
4.RESULT & DISSCUSSION



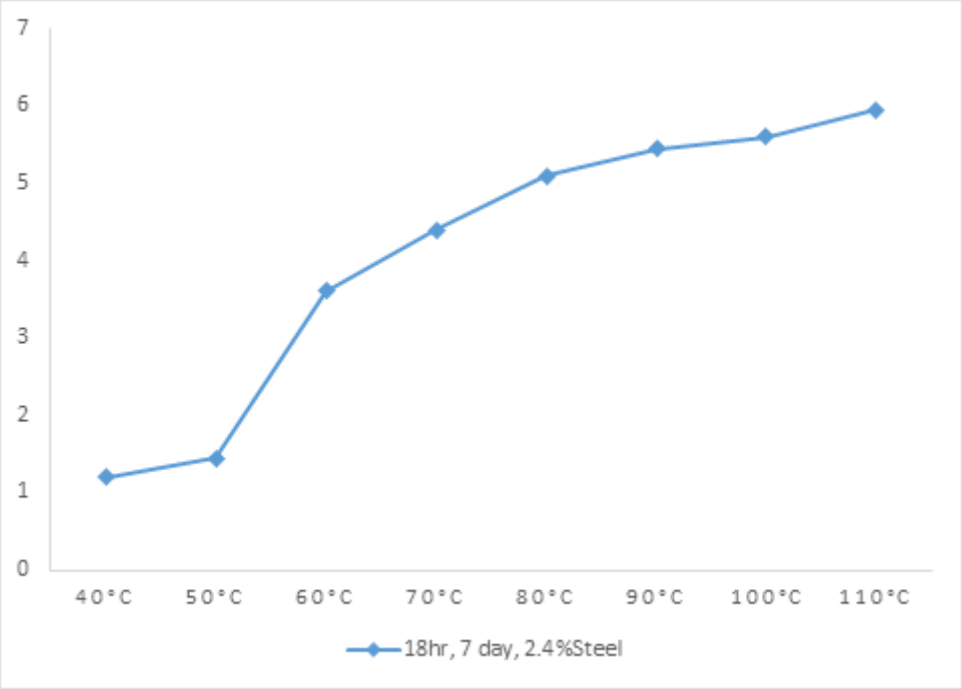
Graph – 1 Temperature Vs Compressive strength



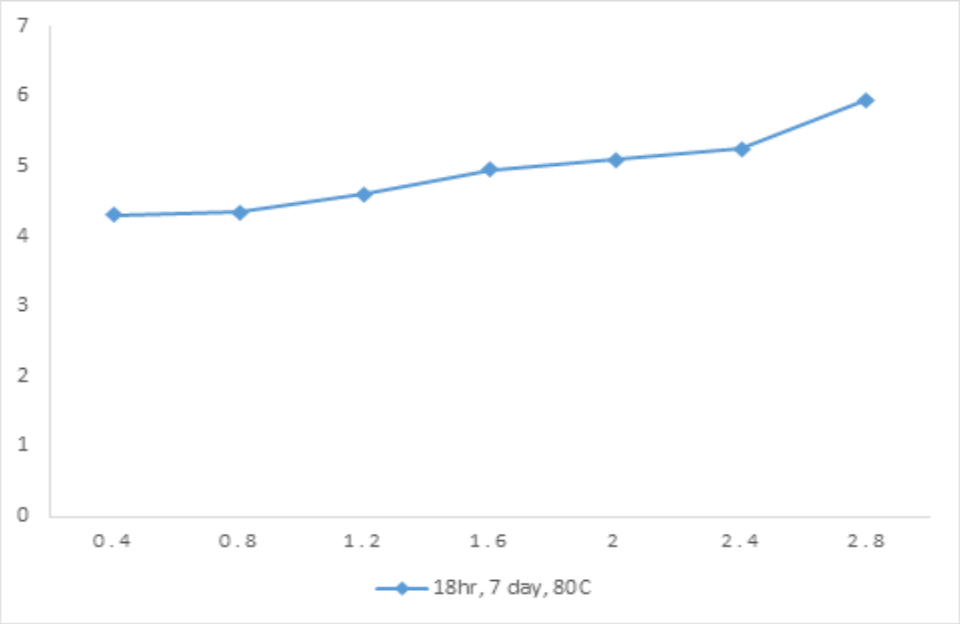
Graph – 2 Percentage of fiber Vs Compressive Strength



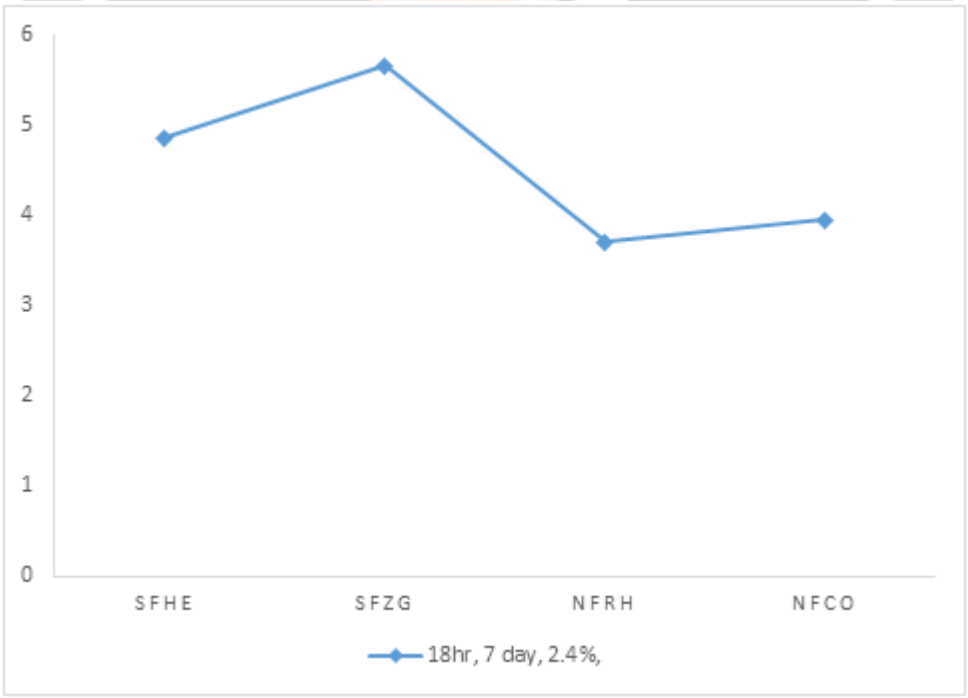
Graph – 3 Compressive Strength of Different Fibers



Graph – 4 Temperature Vs Split Tensile strength



Graph – 5 Percentage of fiber Vs Split Tensile Strength



Graph – 6 Split Tensile Strength of Different Fibers

5. CONCLUSIONS

1. Percentage of steel fibers plays an important role to increase compressive strength of fly ash based geopolymer concrete reinforced with steel fiber.

2. Geopolymer concrete is more brittle than conventional concrete, steel fibres are used to make it an elastic one.

3. Compressive strength of the Geopolymer concrete with fibers has increased.

4. Split tensile strength of Geopolymer concrete with fibers has increased.

5. Low-calcium fly ash-based geopolymer concrete has excellent compressive strength and is suitable for Structural applications.

6. REFERENCES

1. P.Eswaramoorthi, G.E.Arunkumar,"Fibers Study On Properties Of Geopolymerconcrete With Polypropylene", International Refereed Journal of Engineering and Science (IRJES) ISSN (Online) 2319-183X, (Print) 2319-1821 Volume 3, Issue 2 (February 2014)
2. A.Priyanka, Dr.J.Jegan,"Influence of Steel Fibre in Geopolymer Concrete", (ISSN 2347-6710 International Journal of Innovative Research in Science, Engineering and Technology)
3. Prakash R. Vora, Urmil V. Dave, "Parametric Studies on Compressive Strength of Geopolymer Concrete", Procedia Engineering 51 (2013) 210 – 219, Published by Elsevier Ltd.
4. Behzad Nematollahi, Jay Sanjayan, Jessie Xia Hui Chai and Tsui Ming Lu, "Properties of Fresh and Hardened Glass Fiber Reinforced Fly Ash Based Geopolymer Concrete" Key Engineering Materials Vols. 594-595 (2014) pp 629-633 © (2014) Trans Tech Publications, Switzerland
5. Subhash V. Patankar, Sanjay S. Jamkar, Yuwaraj M.Ghugal, "Effect of Water-to-Geopolymer Binder Ratio on the Production of Fly ash Based Geopolymer Concrete" International Conference on Recent Trends in engineering & Technology - 2013(ICRTET' 2013).
6. Sandeep L. Hake, Dr R. M. Damgir, Dr S.V. Patankar "State of Art- Investigation of method of curing on geopolymer concrete" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 12, Issue 3 Ver. I (May. - Jun. 2015).
7. Djwantoro Hardjito, Steenie E. Wallah, D. M. J. Sumjouw and B.V. Rangan, "Properties of Geopolymer Concrete with Fly Ash as Source Material: Effect of Mixture Composition", Seventh CANMET/ACI International Conference on Recent Advances in Concrete Technology, Las Vegas, USA, 26-29 May, 2004.
8. Djwantoro Hardjito, Steenie E. Wallah, D. M. J. Sumjouw and B.V. Rangan, "Fly ash-Based Geopolymer Concrete, Construction Material for Sustainable Development", Invited paper, Concrete World: Engineering and Materials, American Concrete Institute, India Chapter, Mumbai, India, 9-12 December 2004
9. Subhash V. Patankar, Yuwaraj M. Ghugal, Sanjay S. Jamkar "Selection of Suitable Quantity of Water, Degree and Duration of Heat Curing for Geopolymer Concrete Production" Proceedings of 3rd International Conference on Recent Trends in Engineering & Technology (ICRTET'2014).
10. V. M. Malhotra and A. A. Ramezanianpour "Fly ash in concrete," Canada Centre for Mineral and Energy Technology (CANMET) September 1994, pp.1-253.
11. Prabir K. Sarker , Rashedul Haque , Karamchand V. Ramgolam "Fracture behaviour of heat cured fly ash based geopolymer concrete" Journal of Elsevier 11 August 2012
12. Vaibhav A. Kalmegh, Dr. P.P.Saklecha, Prof.R.S.KedSar-2015. "Experimntal Study on Geopolymer concrete with fly ash".
13. Sunil a a George, Dr .R. Thenmozhi "Flexural Behaviour of Activated Fly Ash Concrete" International Journal of Engineering Science and Technology (IJEST), Vol. 3 No. 10 October 2011.
14. Sukhvarsh Jerath, Nicholas Hanson "Effect of Fly Ash Content and Aggregate Gradation on the Durability of Concrete Pavements", ASCE, Journal of Materials in civil engineering, Vol. 19, No. 5, May 1, 2007.
15. Vanita Aggarwal, Dr. S.M.Gupta, Dr.S.N.Sachdeva "CONCRETE DURABILITY: Through High Volume Fly ash Concrete (HVFC) A Literature review" International Journal of Engineering Science and Technology Vol. 2(9), 2010.