Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(4), 1803-1808 | ISSN:2251-6727

Review Study of Mechanical Property of Flyash Based Geopolymer Concrete

Abhishek Yadav[1]*, Vikas Srivastava[2], Ashok Kumar Tiwari[3]

[1]*Phd Scholar, Department of Civil Engineering, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj, U.P, India.
[2]Associate Professor, Department of Civil Engineering, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj, U.P, India.
[3]Vice President (Technical and Quality) Ultra Tech Cement Limited, India.

(Received: 05 June 2023 Revised: 14 October 2023 Accepted: 24 November 2023)

KEYWORDS
Alkaline activator, Compressive Strength, Carbon dioxide (CO_2) and Geopolymer concrete.

ABSTRACT:
In current years, the application of fly ash as a substitution for ordinary Portland cement (OPC) in concrete has enlarged in importance. Fly ash deployed Geopolymer concrete does not need the Portland cement as a paste in lieuOPC activating geopolymer can be employed with an alkaline activator. Geopolymer is a complex inorganic aluminum-silicate outcome that exhibits good joining properties. Activated Geopolymer binders and aggregates are mixed to manufacture geopolymer concrete which is an absolute construction material for frameworks. Fly ash is an industrial outgrowth that cost less, is excessively available, and needs to be utilized in an environmentally friendly way, utilization of fly ash as a Geopolymer concrete is healthier for the environment. Utilization of Geopolymer concrete as an substitute for conventional concrete reduces greenhouse gas emissions that are excessively increased by the production of cement. The present review is a complete abridgement of the studies directed on fly ash deployedgeopolymer concrete and depending factors that impact the basicproperties of the geopolymer concrete in the hardened andfresh states.

1. Introduction

The stipulation for concrete as an erection material has increased because of the increase in demand for the infrastructural cover of the world. Nevertheless, the application of cement contaminates the environment and consumes raw substances (limestone). The mass construction of ordinary Portland cement (OPC) needs the combustion of huge amount of fuel as well as the putrefaction of limestone, evolving in notable discharge of CO2 (Bakri et al.,2011). Mass production of Portland cement is aenvironmental wealth-overtiring, energy-rigorous process that frees huge quantity of greenhouse gas (Carbon dioxide gas) into the environment. Portland cement manufacturing of about 1 ton requires 2.8 tons of raw ground material moreover fuels and other essential material in addition. (Reddy et al.,2010) .Production of Portland cement is polluting our environment because of carbon dioxide emission, for reducing the carbon dioxide emission there is a need of development of greener concrete that do not harm our environment geopolymer concrete is solution of that problem. Manufacturing of Geopolymer concrete is mainly possible due to availability silica and alumina based parent material. It provides a outstanding opportunity to shape up environmental friendly Concrete while it is feasible to employ a factory spin-off such as Fly Ash, to bulkily restore the utilization of Ordinary Portland Cement in the Concrete, and consequently lessen the excretion of CO_2 to the environment. (Hardjito et al.,2004). Future of concrete technology will change in next few upcoming years, like we allare observing the change in module of commodities market demand and supply. Consumers requires less price and highly productive articles, apart from this, in this modern era people become aware against the safety of environment and prefer to buy those things which are cheaper, productive and environment friendly. The concept of Geo Polymer concrete satisfies the all aspect of morden consumer without compromising the strength parameter Geo Polymer concrete is good alternative of ordinary concrete, many other pozzolonic materials like Ground Granulated Blast Furnace slag (GGBS),

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(4), 1803-1808 | ISSN:2251-6727

Corn Cob Ash, Rice Husk Ash & Bagasse Ash can also be used in Geo Polymer Concrete.

1.1 Properties of Flyash

It is a spin-off of the ignition of coal in huge power plants. As Stated by the American Society for Testing and Materials, there are dual divisions of fly ash,Class C and Class F Fly Ash. Fly Ash Chemical compositions percentage analyzed by different authors are tabulated below:

Chemical Composition	Patankar etal.,2013	Muhammad etal.,2019	Hardjito etal.,2004	Hardjito etal.,2005	Reddy etal.,2010
SiO_2	77.10	59.92	47.8	53.36	92.65
Al_2O_3	17.71	22.39	24.40	26.49	
Fe_2O_3	1.21	5.97	17.40	10.86	
CaO	0.62	3.87	2.42	1.34	1.34
MgO	0.90	0.67	1.19	0.37	-
SO_3	2.20	0.61	0.29	0.80	-
Na_2O	0.80	0.18	0.31	1.47	0.051
K_2O	-	1.63	0.55	0.77	-
TiO_2	-	1.42	1.328	1.43	-
P_2O_5	-	0.73	2.00	1.70	-
LOI	0.87	3.33	1.10	1.39	1.63

Table.1 Property comparison of fly ash by different author

Fly Ash is very good choice material for Geo Polymer Concrete due to its particle size (silty sized), in spherical shape ,generally ranging between 10 to 100 micron. Due to its spherical size it helps in enhancing the workability of Geo Polymer concrete. Fly is outcome of coal combustion industry, available in abundance and its use in concrete technology is healthy for environment.

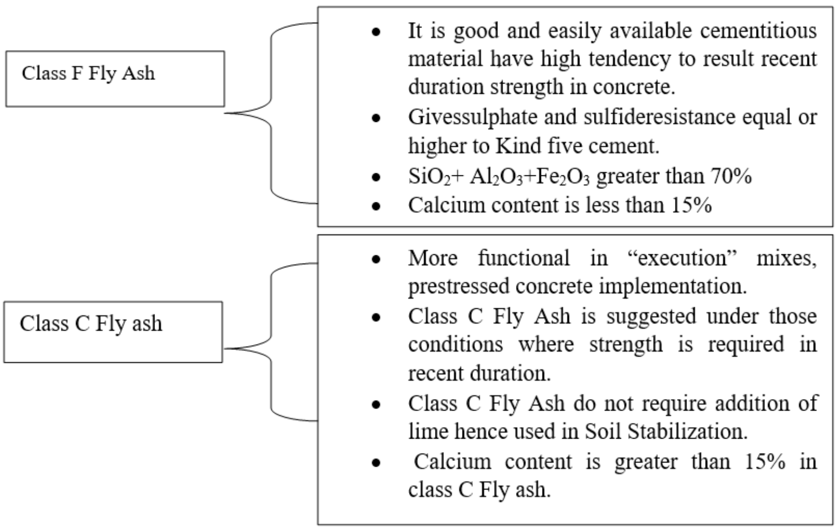

Fig.1 Fly ash classification summary (Zerfu and Ekapurti,2016)

However, for extensive mingle, the kind and order of the mixer used (including speed of rotation as well as charge size), and the point in time of paste control the right mingle time. As a result, fly ash-deployed geopolymer concrete can grasp additional mixing time approximately twenty to thirty minutes. Class-C Fly Ash mixture possess a quick set up time so the large quantity of blend should be circumvented. To the contrary, a mixture of class F fly ash has tendency of higher setting time. For that reason, the combining time is cannot be taken as standard for each batch slot. (Zerfu and Ekapurti, 2016).

1.2 Polymerization Mechanism

Geopolymer paste belongs to the family of inorganic polymers. Zeolitic materials has same chemical

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(4), 1803-1808 | ISSN:2251-6727

composition as that of geo polymer material but their microstructure nature is different, geopolymer has amorphous and zeolitic material has crystalline microstructure. The polymerization method is basically a kind of rapid chemical reaction under the effect of alkaline solution having Si-Al bonded atoms that out- turn three dimensional polymeric lattice and chain structure containing of -Si-O-Al-O bonds. Geopolymer mechanism is based on polymeric condensation of aluminum and silica in the presence of highly concentrated alkali content to achieve structural strength, but in case of ordinary Portland cement structural strength is due to calcium silicate hydrate(C-S-H) bond matrix formation.(Joshi and kadu, 2012).It is found in various research conducted earlier geopolymer concrete is alkali activated alumino silicate (Chemical composition of source material) binder. Geopolymer concrete on the whole be made of geopolymer blend, aggregates, and amalgams. In fly ash deployed alkali-operatedblend, the principal wrappersource stuff is fly ash. As it narrates in figure.1, it is used as a sheath source stuff specially wealthy in alumina-silicate deposits (Zeru and Ekapurti, 2016).

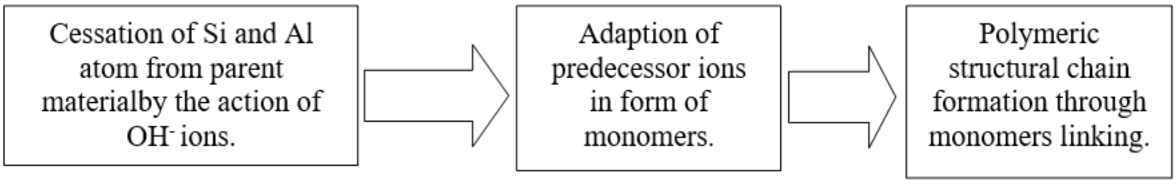

Fig.2 Polymerisation Mechanism of Flyash based Geopolymer Concrete

1.3 Mixing process

In various previous research studies it is found that, the usual substances used as alkaline activators are potassium hydroxide, sodium hydroxide and sodium silicate. In the any geopolymer concrete mixture, sodium-deployed solutions were more recommended in comparisons of potassium deployed solution because sodium deployed solutions are proportionally less costly and easily obtainable in the retail and testing labs in the shape of granular little balls and gel (aqueous). That which founds that the mass ratio of alkaline suspension to Fly Ash source material is taken 0.350 and the recommended mass ratio of alkaline activators sodium silicate to sodium hydroxide is taken 2.500 results in the most appropriate compaction strength. In parallel, 12 molarity concentration of NaOH(Sodium Hydroxide) is eventually the majorly suggested solution by knowing that it gives little less strength in comparisons of 14 molarity and 16 molarity solutions, in which the hindmost gives denser and less practice able geopolymer paste. It shows that the Compressive Strength of Geo-Polymer Concrete is directly proportional tothe Molarity of an Alkaline Activator solution. (Zerfu and Ekapurti, 2016).

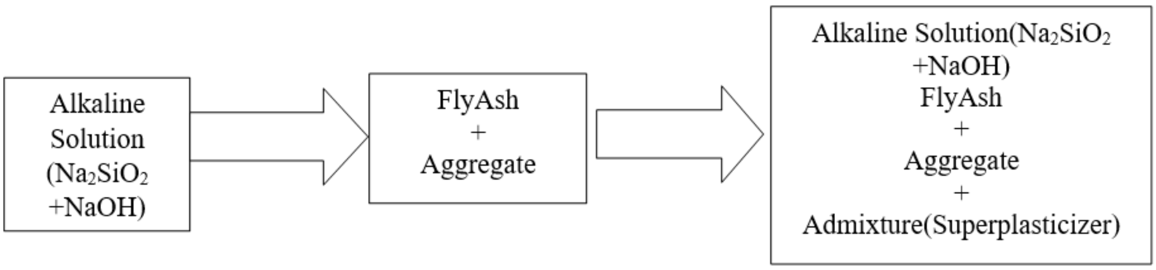

Fig.3 Summay of concrete and mixing

2. Geopolymer concrete Workability

Ratio of H_2O to Geo-polymer sheath is the proportional ratio of the entire amount of H_2Orequired (amount of H_2O available in suspension presently and additional amount H_2O mixed in the blend) to the Geo-Polymer sheath paste (amounts of sodium silicate, Fly Ash, and NaOH (Sodium Hydroxide) aqueous suspension). Fig.1 reports the influence of the ratio of H_2O to Geo-Polymer binder ratio on workableness in form of the flow ability of Fly Ash-deployed Geo-Polymer Concrete by varying the amount of H_2O. That which found that the flow ability is directly proportional to water to Geo-Polymer binder ratio on keeping the other aspects constant (Patankar et al.,2013). In its fresh phase, the geopolymer concrete has a firm evenness. Despite the fact that enough compaction was attainable, an advancement in the workableness was think about as advantageous. The introduction of a large-scale water-lowering amalgam enhance the workableness of the fresh concrete but has

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1803-1808 | ISSN:2251-6727

very small impact on the compressive strength up to about 2% of this amalgam to the quantity of fly ash by mass. (Hardjito et al.,2004)

3. Curing temperature

The strength of specimen increases swiftly with the increase in times up to 28 days, under ambient curing conditionin parallel when the specimens achieved their required target strength. It is observed that the compressive strength was increases by increasing the curing temperature steadily up to the 80 °C curing temperature but then at 100 °C curing temperature, the strength decreased abruptly. Alike outcomes were found in concrete testing blocks (Specimen) cured atambient temperature. It is concluded that at eminent temperature ranges, Geo-Polymer state probity will be grandiose. The geopolymer concrete specimens twenty-eight days compressive strength either cured at ambient temperature or elevated temperature has approximately same strength except the concrete specimen cured at 80 degrees Celsius. It is found that the strength development in tested concrete specimen depends on the heat curing temperature of specimen. (Muhammed et al.,2019). Curing temperature of concrete specimen is directly proportional to compressive strength of specimen, mainly up to 75º C. (Hardjito et al.,2004). Curing time span and temperature are two parameter that play vital role in alkaline activation of fly ash deployed geopolymer concrete to acquire most possible Compressive strength potential. The most appropriate curing thermal temperature to be found is 80 °Celsius. The compressive strength of fly ash deployed geopolymer concrete decreased with the increase in the temperature after 80 °C causing a pessimistic result on the physical properties of the fly ash deployed geopolymer concrete. (Muhammed et al., 2019).

4. Compressive strength of concrete

The compressive strength of geopolymer concrete is independent of the duration of the concrete, lengthy curing time enhances the polymerization procedure develops the greater compressive strength (Hardji to et al.,2004)

The workableness of Geo-Polymer Concrete gets decreased with excessive attentiveness of sodium hydroxide (in the scale of 10 Molarity to16 Molarity) suspension which sequels in greater Compressive Strengths. There is a little rise in the Compressive Strengths with the lifetime of the composite concrete for a reported attentiveness of Sodium Hydroxide solution. (Reddy et al.,2010)

The inclusion of large- scale water-Lessing amalgam, approximately 2% of fly ash by mass, improves the workableness of fresh geopolymer concrete with a very minor impact on the compressive strength of hardened concrete, higher attentiveness (in concern of the Molarity) of Sodium Hydroxide aqueous suspension results in a greater Compressive Strength of Fly Ash deployed Geo-Polymer concrete, greater the ratio of Na_2SiO_3 to NaOH aqueous ratio by Mass, outcomes in greater Compressive Strength of Fly Ash deployed Geo-Polymer Concrete. (Hardjito et al.,2004)

It is found that the effect of Sodium Hdroxide(NaOH) Molarity, Fly Ash to Alkaline animator Ratio, Na_2SiO_3/NaOH Ratio, and Curing thermal temperature are obligatory for attaining the most appropriate Strength of Geo-Polymer, the longevity of the Fly Ash deployed Geo-Polymer is superior to Ordinary Portland Cement when lay bared to an harsh surrounding environment. (Bakri et al., 2011).

It is found that employing fly ash-deployed geopolymer concrete has numerous welfares in regarding economy, environmental protection and engineering property, in comparisons of conventional Portland cement concrete. Fly Ash-deployed Geopolymer concrete is the principle economic alternative of Portland composite cement concrete, i.e., has hindrance to corrosion and reduction in environmental contaminations. (Zerfu and Ekapurti, 2016).

Higher mixing time results in a further down slump of freshly prepared concrete, excessive Compressive strength, and larger denseness of rigid Concrete. This indicates the higher combining time resulted in a superior polymerization activity, and consequently intensified belonging of rigid Concrete. (Hardjito et al.,2005).

The Compaction strength of fly ash deployed Geo-Polymer Concreteen larges with enlargement in H_2O to geoplymer paste ratio and falls with enlargementin H_2O to Geo-Polymer paste ratio, alike to H_2O Cement ratio in Conventional Concrete. (Patanker et al.,2015).

Fly ash-deployed geopolymer concrete with 12 morality (Sodium Hydroxide) NaOH concentration gives higher compressive strength in both oven heat curing and room temperature curing Conditions (Muhammad et al.,2019).

In a comparison of hot air oven curing and curing by direct sunlight, oven curing specimens results in higher compressive strength but sunlight curing is practically convenient. (Jaydeep and Chakravarthy 2013).

5. Conclusions

1. Compressive Strength of Flyash deployed Geopolymer concrete increases the molarity of NaOH and recommended value of molarity of NaOH is between 9 to 14.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1803-1808 | ISSN:2251-6727

2. Strength of fly ash deployed geopolymer concrete depends upon the curing temperature of concrete, recommended curing temperature range from 60 to 80 degrees.
3. Oven curing of concrete gives a sudden increase in strength of concrete for the first 24hrs then decrease and then further decrease but room temperature curing of concrete provides consistent strength results. Curing after 48 hrs does not give promising results.
4. Fly Ash deployed Geopolymer concrete forms by activating fly ash with alkali activators generally sodium-based alkali activators are used as an activator, the recommended value of the proportion of sodium silicate to sodium hydroxide ranges among 2.0 - 2.5.
5. The Recommended ratio of fly ash binder to sodium-based alkali activator ranges between 3 to 3.5.
6. Inclusion of super plasticizer in fly ash deployed geopolymer concrete does not contribute to strength but makes the geopolymer concrete workable, recommended range of super plasticizer in fly ash deployed on geopolymer concrete is 1.5 to 2.0.
7. Bond strength of fly ash deployed geopolymer concrete is better compared to ordinary Portland cement concrete.
8. Fly ash deployed geopolymer concrete has approximately half creep coefficient contrast to ordinary Portland deployed cement concrete.
9. Fly ash deployed geopolymer concrete is highly corrosion resistant and environmentally friendly compared to ordinary cement concrete.

Acknowledgments
The author would like to acknowledge the support of Sam Higginbottom University of Agriculture Technology and Science (SHUATS), for providing resources used in conducting the review work.

References

1. A. M. M. Al Bakri, H. Kamarudin, M. Bnhussian, I. Khairul Nizar, A. R.. Rafizaaand Y. Zarina (2011) “The Processing, characterization, and properties of flyash based geopolymer concrete”, Academia.
2. Ashwini N, Prashanth M.J, Shreyas S Murthy, Supriya L & Shashi Kumara S.R(2019) “Flow and strength performance of geopolymer mortar partially replaced with sub-surface rock powder” International Journal of Engineering Sciences & Research Technology, Issn: 2277-9655.
3. Asraar Anjum, (2019) “Effect of Alkaline Activators, Binders and Fibers on Strength Development of Geopolymer Mortar”, International Journal of Recent Technology and Engineering (IJRTE)ISSN: 2277-3878, Volume-8 Issue-3, Pg No.-4773-4780.
4. Athulya N Ajay, Elba Helen George (2018) “Experimental investigation on effect of inclusion of hooked steel fiber on ggbs based geopolymer concrete” International Journal Of Engineering Sciences & Research Technology),Issn: 2277-9655.Pg no. 716-723.
5. B. SivaKonda Reddy, J. Varaprasad and K. Naveen Kumar Reddy (2010) “Strength and workability of low lime fly-ash based geopolymer concrete”, Indian Journal of Science and Technology, Vol.3 No.12, ISSN: 0974-6846.
6. Brett Tempest, Clarke Snell, Thomas Gentry, Maria Trejo, and Keith Isherwood (2015), “Manufacture of full-scale geopolymer cement concrete components: A case study to highlight opportunities and challenges” PCI Journal, pg no. 39-49.
7. Caijun Shi, LinlinChong, Xiang Hu and XiaojinLiu (2015) “Geopolymer: Current status and research needs” (Article in Indian Concrete Journal) 2015,. The Indian Concrete Journal, Vol. 89, Issue 2, pp. 49-57.
8. D. Hardjito, S.E. Wallah, D.M.J. Sumajouw and B.V. Rangan(2004) “Fly ash-Based Geopolymer Concrete, Construction Material for Sustainable Development”, Invited paper, Concrete World: Engineering and Materials, American Concrete Institute, India Chapter, Mumbai, India,, Pgno.- 9-12.
9. Djwantoro Hardjito, Steenie E. Wallah, Dody M.J. Sumajouw and B.V. Rangan (2004) “Factors influencing the compressive strenght of Fly-Ash based geopolymer concrete”, Civil Engineering Dimension, ISSN 1410-9530, Vol.6, No.2, 88-93.
10. Djwantoro Hardjito, Steenie E. Wallah, Dody M.J. Sumajouw, and B. Vijaya Rangan (2004) “On the development of Fly-Ash Based Geopolymer Concrete”, ACI Materials Journal, V.101, No.6.
11. D.Hadjito. S.E. Wallah, D.M.J. Sumajouw, B.V. Rangan (2005) “Introducing Fly Ash- based geopolymer concrete: Manufacture and engineering properties” 30th Conference on Our World in Concrete & Structures, pg.23-24.
12. E. Rabiaa, R. A. S. Mohamed, W. H. Sofi and Taher A. Tawfik, (2020) “Developing Geopolymer Concrete Properties by Using Nanomaterials and Steel Fibers”, (Hindawi) Advances in Materials Science and Engineering, Volume 2020, Article ID 5186091, 12 pages.
13. Hakan Tacettin Turker, Muzeyyen Balcikanli, Ibrahim Halil Durmus, Erdogan Ozbay, Mustafa Erdemir (2016) “Microstructural alteration of

alkali activated slag mortars depend on exposed high temperature level", Article in Construction and Building Materials, pg.169–189.
14. Ishwar Chandra Thakur, N.Kisku , J.P.Singh, Sheo Kumar(2016) "Properties Of Concrete Incorporated With Ggbs" Volume: 05 Issue: 08, eISSN: 2319-1163 | pISSN: 2321-7308.pg no.-275-281.
15. KefiyalewZerfu and Januarti Jaya Ekapurti (2016) "Review on Alkali-Activated FlyAsh based geopolymer concrete", MaterialScience Forum, Vol.841pp 162-169.
16. Mr. Gautam L, Miss K.T. Sheethal, Dr. Prema Kumar W. P., Dr. Prathap Kumar M. T. (2015) "Development of High Strength Geopolymer Concrete using Low Molarity Naoh" International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 4 Issue 07, July-2015, Pg no.194-200.
17. M.I. Abdul Aleem and P.D. Arumairaj (2012) "Optimum mix for the geopolymer concrete" Indian Journal of Science and Technology, ISSN: 0974- 6846. Pgno.2299-2301.
18. N. P. Vignesh, K. Mahendran, and N. Arunachelam, (2020) "Effects of Industrial and Agricultural Wastes on Mud Blocks Using Geopolymer", Hindawi Advances in Civil Engineering, Volume 2020, Article ID 1054176, 9 pages.
19. Norhasni Muhammad, ShahrizanBaharom, Noor Amirah Mohamed Ghazali, Noor Asiah alias (2019) "Effect of Heat Curing Temperatures on Fly Ash-Based Geopolymer Concrete", International Journal of engineering & Technology, pg. 15-19.
20. Puput Risdanareni, Ekaputri Januarti Jaya And Mohd Mustafa Al Bakri Abdullah (2015) "Effect of Alkaline Activator Ratio to Mechanical Properties of Geopolymer Concrete with Trass as Filler", Applied Mechanics And Materials, Vols. 754-755, pp 406-412.
21. P.Santosh, AVS Sai Kumar, Dr. VVRLS Gangadhar (2016)"Flexural response of hybrid fibre reinforced geo polymer concrete", International Journal Of Engineering Sciences & Research Technology, Issn: 2277-9655.
22. S. Kavipriya (2019) "Mechanical Strength Properties of Geo Polymer Concrete incorporating Quarry Rock Dust and Recycled Coarse Aggregate" International Journal of Recent Technology and Engineering, ISSN: 2277-3878, Volume-8, Issue-4.
23. Solomon Oyebisi, Anthony Ede, Festus Olutoge, Olatokunbo Ofuyatan, John Oluwafemi (2016) "Influence of alkali concentrations on the mechanical properties of geopolymer concrete", IJCIET, volume 9, issue 8, pp. 734–743.
24. S. Jaydeep and B.J. Chakravarthy (2013) "Study on fly ash based Geo-Polymer concrete using admixtures", International Journal of Engineering Trends and Technology, Volume 4 Issue 10.
25. Subhash V. Patankar, Sanjay S. Jamkar and Yuwaraj M. Ghugal (2013) "Effect of water to Geopolymer binder ratio on the production of flysh based Geopolymer concrete" International Journal of Advanced Technology in Civil Engineering, ISSN: 2231-5721, Volume-2, Issue-1.
26. S.V. Joshi and M.S. Kadu(2012) "Role of Alkaline Activator in Development of Eco-friendly Fly Ash Based Geo Polymer concrete", International Journal of Environmental Science and development, Vol.3, No.5.
27. Wallah, S.E(2012) "Creep Behavior of Fly Ash-Based Geopolymer concrete "Creep Behaviour of Fly Ash- Based Geopolymer Concrete", Civil Engineering Dimension, Vol.12, No. 2, pg. 73-78, ISSN 1410-9530.