Performance of Geopolymer Concrete By Using Waste Material

Arjun Subhash Ghodake[1], Prof. Nikhil H. Pitale[2]
[1, 2] Department of Civil Engineering
[1, 2] G.H.Raisoni College of Engineering, Hingana Road, Nagpur

Abstract-*As we know the world is facing pollution problem. The global use of concrete is second only to water. The cement consumption has risen nearly more than 1.3 billion tons per annum.CO2 is emitted during the calcination of limestone, resulting in an approximately 1 ton of CO2 for every ton of OPC produced. So to reduce the Greenhouse gas, we need to control the emission of CO2Therefore its need of the time to not only introduces such materials and technologies for an alternative to the cement but also to use it more and more. Replacing 15% of cement worldwide by other cementations material will reduce CO2 emission by 250 million tons and if it's replaced by 50 %, emission is reduced by 800 million tonnes Our Project Aim is to completely replace the cement by low calcium fly ash which is used as a binder material in Geopolymer Concrete At present nearly 170 million tonnes of fly ash is being generated in India and its utilization is only 25 million tonnes. So the disposal of fly ash and GGBS is also a major issue. So all the researchers have put full efforts in geopolymer concrete. This GPC concrete requires oven curing in different temperature for a time period one day to four days. We are noticed that with variation in materials such as molarity, polymer Activator, catalyst activator, GGBS, Fly ash, curing time and temperature makes the difference in the strength. A lot of information collecting on geopolymer concrete and we are focusing on the gap of research.*

Keywords-GGBS, Fly ash, Catalyst Activator, Polymer Activator, Compressive Strength, Split tensile strength, Molarity, Curing Temperature and time.

I. INTRODUCTION

As we know the world is facing pollution problem. The pollution due to factory smoke or other materials. Basically in civil construction concrete is an important parameter and cement is a main key factor of concrete material. One ton of cement manufacture produced one-tonne carbon dioxide. The carbon dioxide affects human health and surrounding environment. It is responsible for many serious problems. Now the world is focusing on eco-friendly material and products. In this project, attempts are made to replace cement by granulated blast furnace slag (GGBS) and fly ash (FA) which is an industrial waste material. There is also the problem of disposal of this material. An expressive use of granulated blast furnace slag (GGBS) and fly ash (FA) in Geopolymer concrete. Geopolymer concrete has excellent properties, as a researcher has already studied. The main strength of GPC depends on the source of materials, chemical structure, and polymer and catalyst activator solution, the ratio of solution to fly ash, base period, curing type and curing temperature.

As per IS code the cement is replaced by fly ash with 35% weight of cementations material, and it is easily available in the industry. Fly ash is industrial waste material and it is to maintain great mechanical properties with whole durability performance. Another by-product is used such as rice husk, fly ash etc. In this material, there is the presence of aluminum (Al) and silicate (si).Another industrial material is GGBS which is made from iron ore or slag. This material helps to increase the strength of geopolymer concrete. The chemical and physical properties are mention below the point and also the factors that effect on geopolymer concrete cube such as material source, workability, curing period and curing type that is discussed in the paper.

II.LITERATURE REVIEW

Most of the research on geopolymer is already done by the authors some of them follow.

- Joseph Davidovits (1994) studied of properties geopolymer cement carried out by the author. Researcher focused on excellent properties of geopolymer and its use regarding rehabilitation of retrofitting of structures after a disaster. The geopolymer is the best material for retrofitting regarding the environmental and construction usagesAvoid combining CGS and SI units, such as current in amperes and magnetic field in overseas. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.

- Lyon E et al (1996) studied that geopolymer is noncombustible and fire resistive structural materials. Which are suitable for infrastructure where a high degree of fire resistance is needed at low to moderate cost? The main conclusion was entered that load bearing capability

increases with increasing fire up to 1000C temperature might be reached.

- Balaguru. P (1997) from this paper it is being concluded that study has been done with the help of geopolymer concrete for repair and rehabilitation RCC beam. The first objective of this paper was to know whether geopolymer can be used or not for repair of the concrete structure. It has been also concluded that geopolymer concrete has the strongest bond with carbon fabricsEquations.

- Vijaya Rangan B (2004) carried out a study on durability of geopolymer concrete by considering the environmental protection. This paper described the results by conducting the test by large scale reinforced GPC member and also give the application of GPC in the construction industry. The test gave the results regarding excellent to resistance to fire attack and sulphar attack undergoes low creep was noted the based benefit of geopolymer concrete

- Vijaya Rangan et al (2006) studied the behavior of fly ash in GPC and informed that the geopolymer concrete had an excellent strength and is suitable for the constructional applications. The elastic properties of the hardened concrete, as well as the behavior & strength of the reinforced structural members, were similar to those of Portland cement concrete. Therefore, the design provisions present in the current standards and codes can be used to design the reinforced fly ash-based geopolymer concrete structural members.

- Sumajouw D.M.J et al (2006) Studied of the behavior of fly ash and slender reinforced columns. They studied analysis of the behavior and the strength of reinforced geopolymer concrete slender columns. The low calcium fly ash based geopolymer concrete reinforced columns had excellent potential in the precast industry.

- Bhikshma et al. (2010) In this paper author investigated that flexural behavior of high strength manufacture sand concrete. The researcher observes the workability of M50 grade investigated sand concrete is supposed to be 30% less compared to ordinary concrete and compressive strength of M50 grade concrete having varying percentages that are 0%, 25%, 50%, 75%, 100%. Manufacture concrete improves the strengths by 6.89%, 10.76%, 20.68% respectively and the outcome was while comparing to ordinary concrete the load carrying and moment carrying capacity of reinforced concrete beam was 3 to 12 % higher.

- Vijai et al (2010) informed that geopolymer concrete had an excellent compressive strength and it is more suitable for the structural application. The elastic as well as behavior and strength properties of reinforced structure members here similar to those of portland cement concrete. Hence the design provisions according to the current codes and standards can be used to design the reinforced fly ash-based geopolymer concrete member structure.

- LIoyd N.A and B.V Rangan (2010) carried out research on concrete strength and durability of prototype tetrapod and that result is compared with the field and laboratory the main aim of this paper presenting is to investigate the material properties after a long term exposal at sea. There was no degradation was occur after 16 to 24 years.

- Muhd Fadhil Nuruddin et al (2011) Studied out the compressive strength and interfacial transition zone characteristics of GPC with a different cast in situ curing condition. They concluded that curing condition affixes the compressive strength of geopolymer concrete. Therefore proper curing play than important role regarding the acceptable strength of geopolymer concrete structure.

- Ganapathi Naidu.P et al (2012) studied on strength property of geopolymer concrete with the addition of GGBS. The strength properties of geopolymer concrete were studied by using low calcium fly ash replacing with GGBS in five different percentages. From this, it is obtained that compressive strength of geopolymer concrete increasing fly ash percentage with GGBS up to 28.57%, it comes normal and fast setting. They observe 25% loss in compressive strength when geopolymer exposed to a temperature of 500-degree celsius for two hours.

- Abdul Aleem et al P.D (2012) survey on GPC has been done by the researcher. Nowadays geopolymer concrete is going to be used effectively in precast industries due to its high early strength. Using this geopolymer possibility of a large amount of production and mitigate the time and breakage during the transportation. They disclosed the characteristics of geopolymer concrete and announce that geopolymer concrete can be used instead of conventional Portland cement concrete.

- Shankar H Sanni & Khadiranaikar (2012) studied the durability characteristics of geopolymer concrete and compare that characteristic with PPCC specimen. He got the result after seven days of casting, the specimen of

GPC and PPCC were soaked in 10% sulphuric acid. This specimen were kept fully immersed in the solution having four times the volume of the specimen for the duration of the specimen and that effect of the solution on the prescribed specimen were regularly observed with visual inspection measuring the weight and by testing strength. It was concluded that the compressive strength lost for the specimen exposed in sulphuric acid in the range of 10 to 40 % in PPCC while it supposed to be 7 to 23 % GPC.

- Abdul Aleem M.I and Arumairaj (2012) from this paper it is being concluded that the most appropriate mix of geopolymer concrete is they have determined the compressive strength of concrete by using the cubes of size 150X150X150mm and had been cured having steam curing for one day the most approximate mix is (1:1.5:3.3) fly ash: fine aggregate: coarse aggregate with the help of solution catalyst and polymer activator to fly ash ratio of 0.35. With the help of geopolymer mix they got high and early strength of concrete.

- Mahesh Patel et al. (2013) studied that if we are replacing concrete with Geopolymer concrete and crushed sand instead of fine aggregate by crusher sand and cement by GGBS. We were got 20 % replacement of fine aggregate based on compressive and split tensile strength.

- Madheswaran C.K et.al (2013) studied the variation of strength for different grades of geopolymer concrete with different molarities of sodium hydroxide. Different molarities of NaOH i.e. 3M, 5M, 7M. to prepared different mixes and in the ambient temperature it was been cured by using geopolymer concrete mix they got the strength ranging from 15 Mpa to 52 Mpa at the edge of 7 and 28 days with increasing Concentration of NaOH for compressive strength of geopolymer concrete is also varing.

- Yogendra O. Patil et al (2013) carried out an experimental study on GGBS as partial replacement of OPC. They were made to study the flexural and compressive strength of concrete containing variation in GGBS at the edge of 7, 28, 90 days time period. They got the conclusion increasing percentage of GGBS result in strength of concrete. The best replacement of OPC by GGBS was 20%.

- Sonali K. Gadpalliwar et al (2014) carried out a research onto Study the partial replacement of Cement by GGBS and RHA and Natural Sand by Quarry Sand In Concrete.They are using industrial waste material which is replaced by natural sand can be an economic alternative. They have carried out Percentage of Mixing Proportion quarry sand with natural sand is carried out to determine maximum compressive strength. And also a combination of GGBS and RHA various Percentage gives good results.

- Mohemed aquib javeed et al (2015) from this paper it was found that the optimum level of sustainable geopolymer concrete by using the combination of crushed sand and pond ash as a fine aggregate, replacing the natural river sand and using ambient curing to increase strength. So it was observed that if we are going to replace natural sand with 60% of crushed and 40% pond ash we will get favorable strength.

III. DISCUSSION

Studied above research paper Geopolymer is made of GGBS, Fly ash, Polymer Activator, Catalyst Activator. The chemical reacts with the Binding material gets Geopolymerisation Process starts. So, it can be directly affected by the strength of material. The different curing temperature conditions are more effective and workable for all atmospheric conditions. By using different molarities of chemical to check the variation of the strength of GPC. To get increasing the viscosity and reducing the workability of concrete, due to changing molarity.

IV. CONCLUSION

Based on above papers Geopolymer concrete having good compressive strength instead of Cement concrete cement. The temperature is also the main parameter for geopolymer concrete. Geopolymer concrete is fire resistance material and eco-friendly cement product. In the geopolymer concrete, GGBS and Fly ash are playing the vital role instead of cement material. It can be easily available and economical also. Due to increase in the molarity of KOH and NaOH, there is an increase in the viscosity and also the leaching of Si and Al from the fly ash and GGBS particles thus reducing the workability and increase in the strength of concrete. GPC is more homogeneous, well bonded to aggregates; corrosion based improved crack resistance, long term durability than OPC.

REFERENCES

[1] Davidovits, J., (1994), “Properties of geopolymer cement, Proceedings of first International conference on alkaline cement and concretes, 1, SRIBM, Kiev, Ukraine, pp 131-149.

[2] Lyon R.E1, U.Sorathia2, P.N.Balaguru3 and A.Foden4, J. Davidovits and M. Davidovics5. "Fire Response of Geopolymer Structural composites". Proceedings of the First International Conference on Fibre Composites in Infrastructure (ICCI' 96) Tucson, January 15-17, 1996, Dept. Civil Eng., University of Arizona, pp. 972-981.

[3] Joseph Davidovits. "Properties of Geopolymer cements". Published in proceedings First International Conferences on Alkaline Cements and Concretes, Scientific Research Institute of Binders and Materials, Kiev State Technical University, Kiev, Ukraine, 1994, PP. 131-149.

[4] BalaguruP1, Stephen Kurtz 2, and Jon Rudolph 3. "Geopolymer for Repair and Rehabilitation of Reinforced Concrete Beams". Geopolymer Institute 1997 02100 SAINT-QUENTIN – France.

[5] Vijaya Rangan, B, Djwantoro Hardjito, Steenie Wallah, E & Dody MJ Sumajouw 2006, 'Properties and applications of fly ash-based concrete', Materials forum, vol. 30.

[6] Rangan, B. V., (2008), Mix design and production of fly ash based geopolymer concrete, The Indian Concrete Journal, 82, pp 7-14.

[7] Sumajouw.D.M.J1, Æ D. Hardjito2, Æ S. E. Wallah3 Æ B. V. Rangan4. "Fly ash-based geopolymer concrete: a study of slender reinforced columns". J Mater Sci (2007) 42:3124–3130.

[8] Bhikshma, V., Kishore, R and Raghu Pathi, C.V. (2010), "Investigations on flexural behavior of high strength manufactured sand concrete", Challenges, Opportunities and Solutions in Structural Engineering and Construction Ghafoori (ed.)© 2010 Taylor & Francis Group, London, ISBN 978-0-41556809-8.

[9] Vijai, K, Kumutha, R & Vishnuram, BG 2010, 'Effect of types of curing on strength of geopolymer concrete', International Journal of the Physical Sciences, vol. 5(9), pp. 1419-1423.

[10] Lloyd N.A1 and Rangan.B.V2. "Geopolymer Concrete with Fly Ash". Coventry University and the University of Wisconsin Milwaukee Centre for By-products Utilization, Second International Conference on Sustainable Construction Materials and Technologies. June 2010 ISBN 978-1-4507-1490-7.

[11] Muhd Fadhil Nuruddin1, Andri Kusbiantoro2, Sobia Qazi3, Nasir Shafiq4. "Compressive Strength and Interfacial Transition Zone Characteristic of Geopolymer Concrete with Different Cast In-Situ Curing Conditions". World Academy of Science, Engineering and Technology Vol:5 2011-01-24.

[12] Abdul AleemM.I1, P. D. Arumairaj2. "Geopolymer Concrete – A Review". International Journal of Engineering Sciences & Emerging Technologies, Feb 2012. ISSN: 2231 – 6604 doi: 10.7323/ijeset/v1_i2_14 Volume 1, Issue 2, PP. 118122 ©IJESET.

[13] GanapatiNaidu.P1,A.S.S.N.Prasad2,S.Adiseshu3,P.V.V.Satayanarayana4. "A Study on Strength Properties of Geopolymer Concrete with Addition of G.G.B.S". IJERD Volume 2, Issue 4 (July 2012), PP. 19-28.

[14] Shankar H Sanni & Khadiranaikar, RB 2012, 'Performance of geopolymer concrete under severe environmental conditions', International Journal of Civil and Structural Engineering, vol. 3, no. 2.

[15] Abdul AleemM.I1 and ArumairaP.D2 "Optimum mix for the geopolymer concrete". Indian Journal of Science and Technology, Vol. 5 No. 3 (Mar 2012), ISSN: 0974- 6846

[16] Madheswaran.C1, Gnanasundar.G2, Gopala krishnan.N3. "Effect of molarity in geopolymer concrete". INTERNATIONAL JOURNAL OF CIVIL AND STRUCTURAL ENGINEERING Volume 4, No 2, 2013.

[17] Mahesh Patel, Rao P. S. and Patel T. N., 2013, "Experimental Investigation on Strength of High Performance Concrete with GGBS and Crusher Sand", Indian Journal of Research, Vol.3, Issue4, PP. 114116.

[18] YogendraO.Patil1, Prof.P.N.Patil2, Arun Kumar Dwivedi3. "GGBS as Partial Replacement of OPC in Cement Concrete – An Experimental Study". IJSR Volume: 2 /Issue: 11 / November 2013 • ISSN No 2277 – 817.

[19] Sonali K. Gadpalliwar1, R. S. Deotale2, Abhijeet R. Narde3. "To Study the Partial Replacement of Cement by GGBS & RHA and Natural Sand by Quarry Sand In Concrete": (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 2 Ver. II (Mar- Apr. 2014), PP 69-77.

[20] Mohamed Aquib Javeed1, Veerendra Kumar2, Narendra.Dr.H3. "Studies on Mix Design of Sustainable Geo-Polymer Concrete". IJIREM) ISSN: 2350-0557, Volume-2, Issue-4, July 2015