

AN EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF GGBS AND METAKAOLIN IN ADDITION WITH ALKALINE SOLUTION OF SODIUM HYDROXIDE AND SODIUM SILICATE

N. SIREESHA

Department of Civil Engineering
Vikas College of Engineering & Technology
Sireeshan987@gmail.com

B. MADHAVI

Assistant Professor
Department of Civil Engineering
Vikas College of Engineering & Technology
Madhavib96@gmail.com

ABSTRACT:

Today the world facing the is the environmental pollution In the construction industry mainly the production of Portland cement will causes the emission of pollutants results in environmental pollution. We can reduce the pollution effect on environment, by increasing the usage of industrial by-products in our construction industry. Some of the Pozzolanic materials like flay ash, Silica fume, Rice Husk ash, Metakaolin; Ground Granulated Blast Furnaces Slag (GGBS) are used as cementations materials. Among them the Ground Granulated Blast Furnaces Slag,(GGBS) which is the waste from, of iron manufacturing industry, which may be used as substitute of cement in concrete due to its inherent cementing properties. Geo-polymer concrete is such a one and in the present study, to produce the geo-polymer concrete the Portland cement is fully replaced with GGBS (Ground granulated blast furnace slag) and alkaline liquids are used for the binding of materials. The alkaline liquids used in this study for the polymerization are the solutions of Sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3). The objective of this paper is to study the effect of Metakaolin (MK) and ground granulated blast furnace slag (GGBS) on the mechanical properties of geo polymer concrete (GPC) at different replacement levels where the convectional concrete is fully replaced as an cement with met kaolin and the percentage of replacement levels are investigated up to 60%for metakaoline, 40%for GGBS. (MK50-GGBS50, MK40-GGBS60, MK30-GGBS70, MK20-GGBS80, MK10-GGBS90). Sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH) solution have been used as alkaline activators. In the

present investigation, it is proposed to study the mechanical properties viz. compressive strength, split tensile strength of Metakaolin and GGBS based geo polymer concrete. These properties have been determined for M40 mix design at different curing periods like 7, 14, 28, days and at ambient room temperature.

Keywords: Compressive Strength, Alkaline solution, Fly ash, Flexural strength, Ggbs and metakaolin and Water Absorption.

1.0 INTRODUCTION

Concrete is one of the most widely used construction material. Portland cement production is a major contributor to carbon-dioxide emissions. The global warming is caused by the emission of greenhouse gases, such as carbon-dioxide, to the atmosphere by human activities. Among the greenhouse gases, carbon-dioxide contributes about 65% of global warming. Many efforts are being made in order to reduce the use of Portland cement in concrete. These efforts include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and met kaolin, and finding alternative binders to Portland cement. In terms of reducing the global warming, the geo polymer technology could reduce the carbon-dioxide emission to the atmosphere

caused by Cement about 80%. In this project, the effort was made to study the strength parameters of geo-polymer concrete.

OBJECTIVES:

To make a concrete without using cement (i.e. Geo polymer concrete)

- To study the different strength properties of geo polymer concrete with percentage replacement of GGBS.
- To evaluate the optimum M40 Grade mix proportion of Geo polymer concrete with fly ash replaced in various percentage by GGBS.
- To compare the cost variation of geo-polymer concrete with normal concrete

2.0 LITERATURE REVIEW

P. MalleswaraRao K. Hamantha Raja (2017) Geo polymer is need of great importance, where the cover is inorganic polymer. Geo polymer solid will be presented as an option solid which did not utilize any concrete in its blend and utilized Metakaolin and GGBS as option bond. NaOH and Na₂SiO₃ were utilized as activator arrangement. Discoveries: Geo polymer concrete is set up by utilizing the arrangement of sodium silicate blended with sodium hydroxide.

Vinayak Awasare, (2015) In this paper they have contemplated on the GGBS Blended bond cements for M 40 blend outline the compressive quality and flexure quality are resolved with expansion n of 20,30,50.% of GGBS with OPC 53 review cement. And they by reasoned that the standard concrete cement arranged by OPC bond and normal sand of M20 review.

S. Arivalagan (2014) this exploration work is a smothered to build up a greenery

concrete by utilizing a few modern waste material in this report the M 35 blend configuration is utilized the GGBS substitution level is up to 40 % bond substitution, the greatest quality was gotten at the 20 % substitution at 30 years old days. In this report the split pliable and flexure quality are additionally talked about at the substitution level of up to 40 % substitution and mechanical properties are contrasted and typical plain concrete.

Ali Nazari et.al. (2010) studied the combined effect of Nano SiO₂ particles and GGBFS on properties of concrete. They used Nano silica with 3% b.w.c. replacement and 45% b.w.c. GGBFS, which shows improved split tensile strength. An improvement in the pore structure of SCC with silica particles was observed. Apart from this they have studied the effect of ZnO₂ Nano particles on SCC concrete with constant w/c ratio of 0.4. The results showed that by increasing the content of super plasticizer flexural strength decreases.

3.0 METHODOLOGY:

Concrete is a one of the amongst the most broadly utilized development material. Portland concrete generation is a noteworthy supporter of carbon dioxide outflows. The worldwide temperature alteration is caused by the emanation of nursery gasses, for example, carbon dioxide, to the environment by human exercises. Among the nursery gasses, carbon dioxide contributes around 65% of a worldwide temperature alteration. Numerous endeavors are being made keeping in mind the end goal to decrease the utilization of Portland bond in concrete. These endeavors incorporate the use of supplementary establishing materials, for

example, fly fiery remains, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin, and finding alternative binders to Portland cement. In terms of reducing the global warming, the geo polymer technology could reduce the carbon dioxide emission to the atmosphere caused by Cement about 80% In this paper, the effort was There are two main constituents of geo polymers, namely the source materials and the alkaline liquids. The source materials for geo polymers based on alumina-silicate should be rich in silicon (Si) These could be natural minerals such as kaolinite, clays, etc. Alternatively, by-product materials such as fly ash, GGBS, etc. could be used as source materials. The choice of the source materials for making geo polymers depends on factors such as availability, cost, type of application, and specific demand of the end users. The alkaline liquids are from soluble alkali metals that are usually sodium or potassium based.

Table 3.1 Physical Properties of Metakaolin

Colour	Pink / Off-white
Pozzolan Reactivity mg Ca (OH) ₂ / gm	900
Average Particle size	1.4 micron
Brightness (ISO)	75 ± 2
Bulk Density (Gms / Ltr)	320 to 370
Specific Gravity	2.5
Colour	Pink / Off-white

Pozzolan Reactivity mg Ca (OH) ₂ / gm	900
Average Particle size	1.4 micron
Brightness (ISO)	75 ± 2
Bulk Density (Gms / Ltr)	320 to 370
Specific Gravity	2.5

Table 3.2 Chemical Properties of Metakaolin

Al ₂ O ₃	>39.0 %
Fe ₂ O ₃	>0.8%



Figure 3.1. Metakaolin

Sodium hydroxide:

Sodium hydroxide, otherwise called lye and soda, is an inorganic compound. It is one of common activator as well as functions as antacid and helps in the process of geo polymerization, shown in Figure

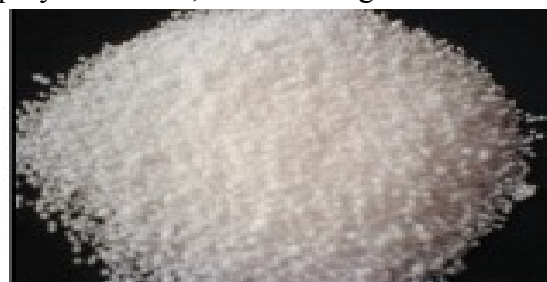
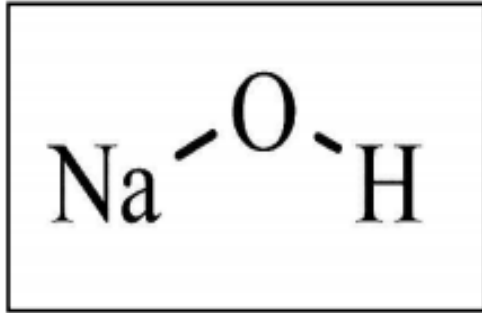


Figure: 3.2. Sodium Hydroxide



**Figure: 3.3. Structure of NaOH
Ultrasonic Pulse Velocity (UPV) Test**

It is a non-destructive testing technique (NDT). The method consists of measuring the ultrasonic pulse velocity through the concrete with a generator and a receiver. This test can be performed on samples in the laboratory or on-site. The results are affected by a number of factors such as the surface and the maturity of concrete, the travel distance of the wave, the presence of reinforcement, mixture proportion, aggregate type and size, age of concrete, moisture content, etc., furthermore some factors significantly affecting UPV might have little influence on concrete strength.

4.0 RESULTS:

UPV Test Results:

Fig 4.1 show UPV test results for specimen for 7 day and Fig 4.2 show UPV test results for specimen for 28 day.

Table 4.1: UPV Test for control specimen for 7th day (7, 14, 28)

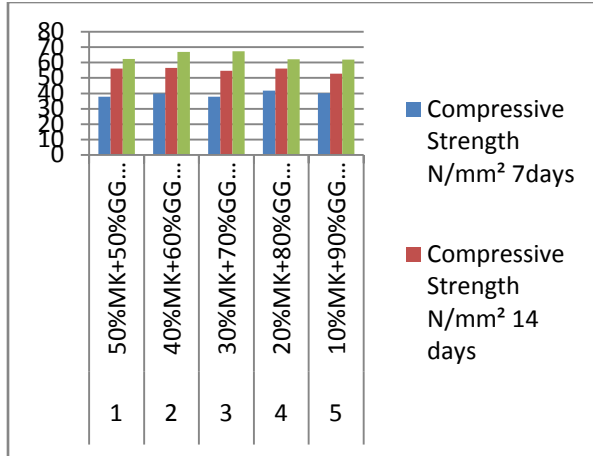
07-DAY TEST RESULT			
Sample No.	Weight (kg)	Velocity (m/s)	Time (µs)
1	8.1	4678	32.2
2	8.34	4702	31.9
3	8.36	4777	31.4

Table 4.2: UPV Test for control specimen for 28 day

28-DAY TEST RESULT			
Sample No.	Weight (kg)	Velocity (m/s)	Time (µs)
1	8.42	4808	31.2
2	8.36	4854	30.9
3	8.14	4777	31.4

Table: 4.3 Compressive strength of various mixes of M40 concrete

S.No	Mix Proportion	Compressive Strength N/mm ²		
		7days	14 days	28 days
1	50%MK+50%GGBS	37.91	56.14	62.44
2	40%MK+60%GGBS	39.81	56.59	66.82
3	30%MK+70%GGBS	37.78	54.66	67.34
4	20%MK+80%GGBS	41.78	56.14	62.22
5	10%MK+90%GGBS	40.15	52.87	61.93

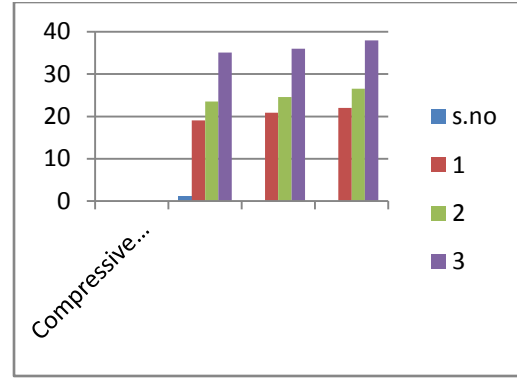


Graph 4.1 Variation of compressive strength of M40 concrete with different % of artificial sand.

Split tensile strength Cylinders of specimen are utilized for testing For 28 days; the tensile strength varies in direct relation with GGBS proportion in the mixture. Split tensile strength shows improved strength of MPa for 10% replacement of met kaolin. ($T = 2P / \pi LD$) The tensile strength of specimen with different proportions are evaluated of age 5, 15 and 30 and a graph is plotted between pozzolanic material proportion (x-axis) vs split tensile strength (y-axis).

Table 4.4: Compressive strength comparison in alkaline attack

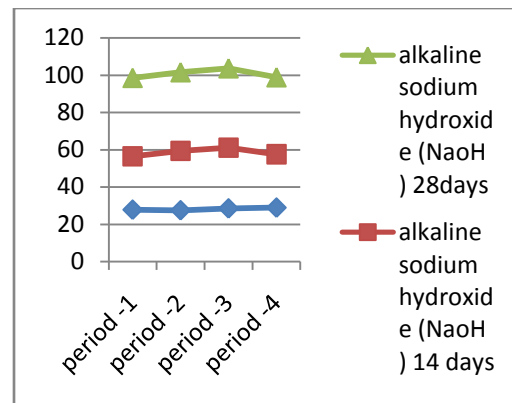
Compressive strength in N/mm ²				
S.No	Age of curing	100%	80%+20%	50%+50%
1	7 days	19.07	20.87	21.99
2	14 days	23.50	24.61	26.52
3	28 days	35.08	35.99	37.97



Graph: 4.2. Compressive strength comparison in alkaline attack

Table 4.5 Immersed 5% by weight of water of sodium hydroxide (NaOH)

Mix	alkaline sodium hydroxide (NaOH)		
	7 days	14 days	28 days
period -1	27.77	28.68	41.98
period -2	27.45	31.88	42.13
period -3	28.45	32.56	42.55
period -4	28.88	28.66	41.22



Graph 4.3 Immersed 5% by weight of water of sodium hydroxide (NaOH)

5.0 CONCLUSIONS

Based on limited experimental investigations conducted on concrete the following conclusions are drawn

- The compressive strength of concrete is found to increase with increase in 50 % Metakaolin and 50% GGBS content. It is found that the strength is increasing from 45.0 to 49.56 MPa i.e., 20%. The split tensile strength of blended concrete is found to vary from 3.4 to 4.56 MPa i.e., approximately equal.
- The strength of the Geopolymer concrete increases with 5%-7% from 5 to 30 days that means there is no much increase in the strength after 8 days.
- The strength of the Geopolymer concrete increases with 8%-10% from 5 to 30 days that means there is no much increase in the strength after 10 days.
- From the above results it is apparent that Geopolymer concrete based on GGBS and metakaolin has got more compressive than conventional concrete.
- Studies can be made on its durability property and to improve its workability characteristics. Fiber reinforced Geo polymer composites may be considered a solution to improve flexural strength and fracture toughness.
- Since there is demand for natural sand, the fine aggregate shall be replaced partially by quarry dust
- Different structural elements like Geopolymer Concrete Beam,

Reinforced Geo polymer Concrete Beam, Reinforced Geo polymer Concrete Columns, Reinforced Beam Column joints shall be cast for the above mentioned concentrations of Sodium Hydroxide solution and curing conditions and tested.

- Chose the above durability alkaline test solution tables and graphs concluded to the 7 and 14 and 28 days Test results indicate that concentration variation of sodium hydroxide had least effect on the fresh properties of SCGC. With the increase in sodium hydroxide concentration, the workability of fresh concrete was slightly reduced; however, the corresponding compressive strength was increased. Concrete samples with sodium hydroxide concentration of M40 produced maximum compressive strength.

6.0 REFERENCES

1. M. Poojitha K. Nirmalkumar, (2010) *Review Paper on Reaction of Alkaline Solution in GEO-Polymer Concrete*, *International Journal on Recent and Innovation Trends in Computing and Communication* ISSN: 2321-8169 Volume: 4 Issue: 10.
2. Ravindra N. Thakur and Somnath Ghosh (2009), "Effect of mix composition on compressive strength and microstructure of fly ash based geo polymer composites". *ARPN Journal of Engineering and Applied Sciences*. ISSN: 1819-6608. Vol.4, pp.68-74.
3. Beny Joseph, George Mathew (2012). "Influence of Aggregate Content on the Behavior of Flyash Based Geo polymer Concrete." *Scientia Iranica* 19(5), pp:1188-1194.

4. Ganapati .N. P., Prasad. A.S.S.N., Adishesu. S and Satayanarayana. P.V.V (2012). "A Study on Strength Properties of Geo polymer Concrete with Addition of G.G.B.S." *International Journal of Engineering Research and Development. Vol-2, pp: 19-28.*
5. Mathew.B.J.,Sudhakar.M and Natarajan.C (2013). "Strength, Economic and Sustainability Characteristics of Coal Ash-GGBS Based Geo polymer Concrete." *International Journal Of Computational Engineering Research. vol-3*
6. Madheswaran.C.K.,Gnanasundar.G. and Gopalakrishnan.N (2013). "Effect of molarity in geo polymer concrete." *International Journal of Civil and Structural Engineering. vol-4*
7. Mathew.G and Mathews. M. P (2014). "Influence of Fly Ash and GGBFS in Laterized Concrete Exposed to Elevated Temperatures." *Journal Of Materials In Civil Engineering, pp:411-419.*
8. Muthusamy.K.,Kamaruzaman.N.W., Mohamed.A.I and Budiea.A.M.A (2015). "Durability Performance of Concrete Containing Laterite Aggregates." *Journal of Civil Engineering. pp:1-8*
9. Muthusamy.K and Kamaruzaman.N.W (2012). "Assessment of Malaysian Laterite Aggregate in Concrete." *International Journal of Civil & Environmental Engineering. vol-2*
10. Muthusamy.K.,Vesuvapateran.G and Kamaruzaman.N.W (2014). "Acid Resistance of Concrete Containing Laterite Aggregate as Partial Coarse Aggregate Replacement." *Research Journal of Applied Sciences, Engineering and Technology , 7(19), pp:3983-3985*
11. Osadebe.N.N and Nwakonobi.T.U (2007). "Structural Characteristics Of Laterized concrete At Optimum Mix Proportion." *Nigerian Journal Of Technology, vol-26 Olubisi A. I (2013), "Performance Of Lateritic Concrete Under Environmental Harsh Condition." International Journal of Research in Engineering and Technology, vol-2.*
12. Fareedahmedmemon, MuhdfadhilNuruddin, Sadaqatullah khan, Nasirshafiq, Tehminaayub (2013) , "Effect of sodium hydroxide concentration on fresh properties and compressive strength of self-compacting geo polymer concrete" *Journal of Engineering Science and Technology Vol. 8, pp.44 – 56.*