

Laboratory Investigation on the Strength and Durability Characteristics of Geopolymer Concrete

Shriram Marathe¹, Pushparaj², Ravikiran N³,

Assistant Professor, Department of Civil Engineering, NMAMIT Engineering College, Nitte, Karkala, Karnataka, India¹

Assistant Professor, Department of Civil Engineering, NMAMIT Engineering College, Nitte, Karkala, Karnataka, India²

P.G. Student, Department of Civil Engineering, NMAMIT Engineering College, Nitte, Karkala, Karnataka, India³

ABSTRACT: Geopolymer concrete is an innovative construction material which shall be produced by the chemical action of inorganic substances. In this experimental investigation, the fly ash is used as a source construction material and along with glass powder, GGBS, and sodium hydroxide flakes is used. In this present study the glass powder is varying percentage of 0%, 5%, 10%, 15% and 20% and small proportion of super plasticizer is used. To obtain optimum percentage of glass powder is obtained from 0% to 20% replacement of fly ash by glass powder, and also study the, obtain optimum percentage of GGBS by obtained value of optimum percentage of glass powder is used, but here % of glass powder is used as constant and the percentage of GGBS is varying form of 5%, 10%, 15% and 20%. Strength parameter such as compressive strength and split tensile strength will be tested for 7 days and 28 days at room temperature.

KEYWORDS: Geopolymer, Compression Strength, Split tensile strength.

I. INTRODUCTION

Generally geopolymer concrete is widely used in all construction practices and nowadays in concrete roads construction, the geopolymer concrete is most preferably used in the rural as well as urban road constructions. The geopolymer concrete consists of the excess amount of industrial waste such as fly ash, GGBS and glass powder. The glass powder is generated from various glass manufacturing industries and fly ash is generated from small as well as large scale, power generated industries. These varieties of waste material is used in manufacturing of geopolymer concrete. The compressive strength of geopolymer concrete depends on the optimum usage of sodium hydroxide used in particular type concrete. Fly ash based concrete gives the better aggression property. It gives the better binding property with NaOH and fly ash.

II. OBJECTIVES OF PRESENT INVESTIGATION

The investigation is carried out on fly ash which is a major type of source material available at UPCL. Objectives of present investigations are:

1. To study the properties of the materials and the suitability of non-conventional method of producing concrete without using conventional Ordinary Portland cement concrete.
2. To determine the effect of varying glass powder on the compressive strength of geo-polymer concrete prepared using trial mix design and obtaining the optimum mix of glass powder.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

3. To study the characteristics of variation of GGBS in the GPC produced using obtained optimum mix design.
4. To investigate the durability aspects of the concrete when exposed to acidic and sulphate environment.
5. Determining the strength properties of concrete for 7, 28 and 60 days after curing in room temperature.

III. LITERATURE REVIEW

Abdul (2012)This paper highlights the strength aspects of geopolymer concrete, it was conclude that, These constituents of Geopolymer Concrete shall be capable of being mixed with a relatively low-alkali activating solution i.e sodium hydroxide flakes(NaOH) and must be curable in a reasonable time under ambient temperature conditions. The production of versatile, cost-effective geopolymer concrete can be mixed and hardened essentially like portland cement. Geopolymer Concrete shall be used in repairs and rehabilitation of concrete works. [1]

Lloyd and Rangan, (2010)this research paper gives the information of geopolymer concrete and properties of materials used in geopolymer concrete. The Higher concentration (in terms of molar) of sodium hydroxide solution results in higher compressive strength of geopolymer concrete is obtained. Higher ratio of sodium silicate solution-to-sodium hydroxide solution ratio by mass, results in higher compressive strength of geopolymer concrete. The slump value of the fresh geopolymer concrete increases when the water content of the mixture increases. Superplasticizers may assist in improving workability. [2]

Susanta (2013).From this paper, the following conclusions can be draw, With the addition of GGBS upto a % of 30% gives a good result in compressive strength under room temperature curing period. More fineness of fly-ash gives more compressive strength, and the increase in fineness the strength of geo-polymer concrete also increase as because it more amount of Si-Al bond is obtained from polymerization process. And higher the silicate modulus ($\text{Na}_2\text{O}/\text{SiO}_2$) the strength of the geo-polymer concrete also increased. Its generates a high early strength as compared to normal cement concrete. [3]

Patil (2014)this paper highlights the Geopolymer concrete shows significant potential to be material for the future work, because it is not only environmentally friendly but also possesses excellent mechanical properties, both in short term and long term and durability of concrete structure. Basic mixture proportions characterized by 75% aggregate to total mass alkaline liquid to fly ash of 0.35 (analogous to water to cement ratio) and elevated temperature curing results in a high strength geopolymer concrete is obtained.[4]

Summary of literature review

In this investigation on the strength and durability characteristics of geopolymer concrete are studied by using the major industrial namely glass powder, fly ash and GGBS. In this work, Fly ash is replaced with 0%, 5%, 10%, 15% and 20% Glass powder for Geo polymer concrete. The Compressive strength test is carried out at the ages of 7, and 28 days. The materials to be used for this study are fly ash, glass powder, fine aggregate, coarse aggregate, sodium Hydroxide flakes (as alkaline solution) and water. The mix proportions prepared for producing this non conventional concrete is by using the available literature.

IV. EXPERIMENTAL INVESTIGATION AND RESULTS

4.1 Materials Used:

To begin with, the fly-ash from UPCL was used as the source material. Along with fly ash, glass powder is also used with varying percentage since finely powdered glass of size less than 600 microns behaves as reactive silica. Sodium hydroxide solution was used as alkaline activator. Mixes in this study is done as per the available literature i.e. by maintaining the ratio of water to fly ash and glass powder is kept as 0.3, ratio of fine aggregate to fly ash and glass powder is kept as 1.5, ratio of coarse aggregate to fly ash and glass powder kept as 2.3. The alkaline activator was maintained at 12M.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

Table 1: Mix Proportions

Mix	Fly ash (kg/m ³)	Fine Aggregate (kg/m ³)	Coarse Aggregate (kg/m ³)	Water (lit./m ³)
	480.33	720.49	1104.76	144.09

4.2 Experimental Investigation:

Table 2: Mix Design values

	0% Glass powder	5% Glass powder	10% Glass powder	15% Glass powder	20% Glass powder
Fly ash	480.33	456.31	432.29	408.28	384.26
Glass powder(kg/m ³)	0	24.02	48.031	72.05	96.07

The table No 2 is generated by replacing the fly ash with varying percentages 0%, 5%, 10% 15% and 20% of glass powder. The small amount of super plasticizer is added to the total mass of concrete. As per the literature says the quantity of super plasticizer is 6liters for one meter cube of concrete. Normally FOSROC SP430 is normally used.

Table 3: Mix Design values

	0% GGBS	5% GGBS	10% GGBS	15% GGBS	20% GGBS
Fly ash	456.32	433.50	410.68	387.87	365.05
Glass powder(kg/m ³)	24.02	24.02	24.02	24.02	24.02
GGBS (kg/m ³)	0	22.82	45.63	68.45	91.26

The above mix design table is obtained from optimum percentage of glass powder is used in table 2 result. The optimum percentage of glass powder is 5 percentages; by using these values the table 3 is generated. Now optimum percentage glass powder is constant that is 24.02kg/ m³.the GGBS is added by replacing the fly ash with varying 5%, 10% 15% and 20%.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016



Figure 1: Compressive Strength of cube specimen



Figure 2: Split Tensile Strength of cylinder specimen

4.3 Results:

- The Table No 4 show the compressive strength test results of cube specimen, using replacement of fly ash by glass powder at the age of 7 days and 28 days curing.
- The Table No 5 show the split tensile strength test results of cylindrical specimen, using replacement of fly ash by ground granulated blasted slag(GGBS) at the age of 7 days and 28 days curing.
- The table No. 6 shows that, the compressive strength test results of cube specimens, using replacement of fly ash by GGBS.

Table 4: Compressive strength test results

Table 5: Split tensile strength test results

Type of mix	7 Days Strength (N/mm ²)	28 Days Strength (N/mm ²)	Type of mix	7 Days Strength (N/mm ²)	28 Days Strength (N/mm ²)
GP ₀	5.33	21.55	GB ₅	1.41	3.11
GP ₅	7.77	23.33	GB ₁₀	1.34	2.89
GP ₁₀	5.33	15.55	GB ₁₅	1.62	2.26
GP ₁₅	4.0	14.89	GB ₂₀	2.26	2.55
GP ₂₀	4.0	16.00			

Table 6 Compression strength test results

Type of mix	7 Days Strength (N/mm ²)	28 Days Strength (N/mm ²)
GB ₅	6.45	18.22
GB ₁₀	11.34	22.00
GB ₁₅	10.00	28.00
GB ₂₀	11.55	18.67

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

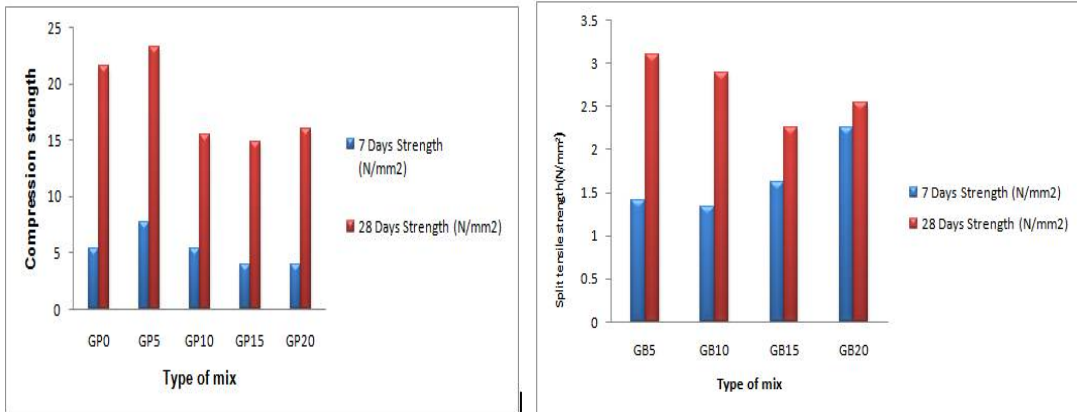


Figure 3: Variation of Compression strength of cube Specimen, using replacement of fly ash by Glass powder. Figure 4: Variation of Tensile strength of cylindrical Specimen, using replacement of fly ash by GGBS.

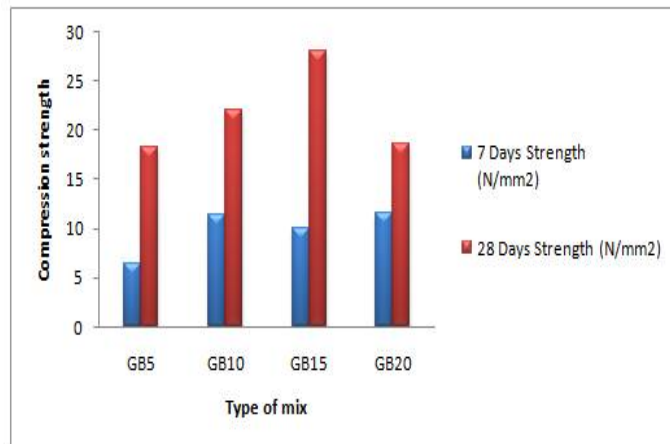


Figure 5: Variation of Compressive strength of cube specimens, using replacement of fly ash by GGBS.

V. CONCLUSION

- 1). From the Figure (3) it is found that GP₅ has attained the maximum compressive strength for both 7 and 28 days. Hence up to 5% replacement of glass powder with fly ash is acceptable.
- 2). The compression test results showed that the increase in the compression strength of concrete sample as the curing period increases as the glass powder is added to geopolymer concrete sample up to 5 percentage glass powder only.
- 3). From the Figure (4) it is found that GGBS₅ has attained the maximum Split tensile strength for 28 days. Hence up to 5% replacement of GGBS with fly ash is acceptable. And it was observed that in same figure, the percentage of replacement fly ash by GGBS is attained, the maximum split tensile strength at 20% addition of GGBS, at the age of 7 days curing period.
- 4). From the table 5 it is found that 15% GGBS has attained the maximum compressive strength for 28 days. And it was observed that as a 7 days compressive strength of cube specimen is obtained at the 20% addition of GGBS it gives the maximum compressive strength.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

ACKNOWLEDGMENT

The authors are thankful to our beloved HOD Dr.Srinath Shetty K, Principal Dr. N Chiplunkar and Faculty Members of Department of Civil Engineering NMAMIT, Nitte for their continuous support to carry out this research work.

REFERENCES

- [1] Dr. S. G Patil "Geopolymer Concrete - A Brief Review", Professor in Civil Engineering PoojyaDoddappaAppa College of Engg. Gulbarga, Karnataka, INDIA (2014)
- [2] M. I. Abdul Aleem and P. D. Arumairaj Assistant Professor (Selection Grade), "Geopolymer concrete- a review", Department of Civil Engineering, Sri Ramakrishna Institute of Technology, Coimbatore, India. Associate Professor in Civil Engineering, Govt. College of Technology, Coimbatore, India..1
- [3] Susanta Banerjee "A Review on Geo-polymer Concrete", *M.Tech scholar*, Department of Civil Engineering, KIIT University, Bhubaneswar, Odisha (2013)
- [4] N A Lloyd, Curtin University of Technology, Australia B V Rangan, Curtin University of Technology, Australia (2010), "Geopolymer concrete : a review of development and opportunities" 35th Conference on our world in concrete & structures: 25 – 27 Singapore.(2010)
- [5] S. Thokchom, P. Ghosh, S. Ghosh. Performance of Fly ash Based Geo-polymer Mortars in Sulphate Solution. *Journal of Engineering Science and Technology Review*. 3(1): 36-40.(2010)
- [6]. S. Thokchom, P. Ghosh, S. Ghosh. Resistance of fly ash based geo-polymer mortars insulphuric acid, *ARNP Journal of Engineering and Applied Sciences*. 4(1): 65-70.2788.(2009)
- [7]. M.I.AbdulAleem, P.D.Arumairaj, "Geo-polymer Concrete- A Review", *IJESET*, Feb-2012, Vol 1, Issue 2, pp: 118-122, ISSN: 2231-6604.
- [8]. S.E. Wallah, B.V. Rangan, "Low calcium fly ash based geo-polymer concrete: Long term properties, Research report GL2", Curtin University of Technology, Australia.(2006)
- [8]. P.Nath, P.K.Sarkar, "Geo-polymer Concrete for Ambient Temperature", Department of Civil Engineering, Curtin University, Kent Street., Bentley, WA, 6102, Australia.
- [9]. S.S.Jamkar, Y.M.Ghugal and S.V.Patankar, "Effect of Fly-ash Fineness on Workability and Compressive Strength of Geo-polymer Concrete", *The Indian Concrete Journal*, pp:57-62.(2013)