International Journal on Emerging Technologies 11(4): 393-396(2020)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

Performance Evaluation of Geopolymer Concrete as Green Construction Material

Pushpendra Singh Palash[1] and Priyanka Dhurvey[2]
[1]*Research Scholar, Department of Civil Engineering, MANIT- Bhopal (Madhya Pradesh), India.*
[2]*Assistant Professor, Department of Civil Engineering, MANIT- Bhopal (Madhya Pradesh), India.*

(Corresponding author: Pushpendra Singh Palash)
(Received 14 May 2020, Revised 18 June 2020, Accepted 29 June 2020)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Geopolymer concrete is an innovative, eco-friendly construction material. It is used as replacement of cement concrete. Being industrial by-products, they are treated such that the pollutants present in them is reduced, as well as price is lower than to Ordinary Cement. Geopolymer concrete is green concrete because in this concrete no cement is used. It is prove that strength is totally dependent on the curing temperature and also curing methods. The heat-curing of fly ash-based geopolymer concrete is recommended and can be achieved by either steam-curing or dry-curing. Heat curing assists the chemical reaction that occurs in the geopolymer binder. Slump value of geo-polymer concrete tends to decrease with increase in molarity. In this study found that compressive strength is high as compare to conventional concrete and flexural strength is low as compare to conventional concrete of M-30 grade. At 12.5 M molarity gives us maximum compressive as well as flexural strength at 60℃ temperature for 24 hours

Keywords: Green Concrete, Geopolymer, Aluminosilicates, Molar Concentration, Alkalination, Geopolymerization.

Abbreviations: NaOH, sodium hydroxide; KOH, Potassium hydroxide; $Na_2Si_2O_3$, sodium silicate and $K_2Si_2O_3$, Potassium silicate.

I. INTRODUCTION

The most common alkaline liquid utilized in geopolymerization may be a combination of caustic soda (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate. Sodium silicate and sodium hydroxide ratio is 2.5 for high strength concrete [1, 10, 13]. Sodium hydroxide (NaOH) used in alkaline liquid as a flack or pallet form and sodium silicate used as solid powder or liquid form. In case both material are used in solid form than the calculated amount in grams or kilogram. If sodium hydroxide is in solid form and sodium silicate is in liquid form than sodium hydroxide solution is 1.3 times of sodium silicate solution. Production of Portland cement is currently 2.6 billion tons per year worldwide and growing at 5 percent annually. Portland cement production may be a major contributor to CO_2 emissions as an estimated 5 -8% you look after all human-generated atmospheric CO_2 worldwide comes from the concrete industry. Geopolymer concrete reduces up to 80% of CO_2 generated due to cement production activities [16]. 1 ton of CO_2 is produced for every 1 ton of cement production [14, 15]. Fly ash-based geopolymer composites exhibited high early compressive strength compared to cement concrete. Higher temperature and higher sodium hydroxide concentration gives highest compressive strength [3-5]. The flexural strength determines the tensile properties of concrete under external loading. The flexural strength of geopolymer concrete is higher than that of cement concrete, which exhibits a decreasing rate of crack propagation due to corrosion of embedded steel bars in the concrete [16]. The split tensile strength is higher than that of cement concrete because of good bonding between the geopolymer paste and aggregates. [16]. Geopolymer concrete exhibits good bonding between the geopolymer paste and aggregates. However, geopolymer concrete has a higher modulus of elasticity than cement concrete [1,3, 5, 6].

II. MATERIALS AND METHODS

The most widely used mineral admixtures in India is fly ash. Although other products such as silica fume, Metakaolin, Rice Husk Ash and natural pozzolan are sometimes utilized, their use is very limited either due to high cost or due to non-availability of materials. Some of these mineral admixtures are waste products of different power and thermal plants, thus pose a serious waste disposal problem and high amount of finance is required to dispose to them.
Hence, by using them in concrete as a partial or total replacement of cement in concrete, can enhance its mechanical concrete as compared to just using OPC. Now a days PPC and PSC are used widely in construction industry.
A brief description of all the constituent materials which are and can be used to make geo-polymer concrete are displayed below. They include.
i. Coarse aggregates:-10mm and 20 mm Sizes of coarse aggregate are chosen for the experimental work
ii. Fine aggregates:- Locally available river sand and which was obtained from river Narmada sand, having a lower size of about 0.07mm was used as a fine aggregate.
iii. Fly ash: For experimental work class fly ash is used.
iv. Alkaline liquids: Combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate.

Fly ash
as per IS 12089–1987

Fine aggregate/sand
as per IS 3812- 2003

Aggregates

Sodium hydroxide

Sodium metasilicate

Fig. 1. Geopolymer ingredients.

III. MANUFACTURE OF GPC

Process of GPC mix as follow:

Step 1 : Alkaline liquid preparation

i. First of all molarities define for geopolymer concrete according to molarities sodium hydroxide quantity is dissolved in water and this quantity is 1 liter.

ii. Sodium silicates quantity according to the sodium hydroxide and sodium silicate ratio. And that quantity is dissolved in 55% of water of total quantity of sodium silicate material.

iii. After 4 hours mix both liquid and that rest for 24 hours.

Step 2: Geopolymer ingredient calculation in surface dry condition

i. All ingredient like fly ash, fine aggregate and course aggregate mixing together in dry condition for 3 to 5 minute in a mixer.

ii. Mixing alkaline liquid in dry mix of geopolymer ingredients.

iii. Finally put in the mould and than curing in hot air oven for three days.

iv. After 3 and 7 days we check harden properties of geopolymer concrete.

Fig. 2. Geopolymer concrete.

IV. RESULTS AND DISCUSSION

(i) Slump Value: Slump Values for Different molarity (In this study we use 10M, 10.5M, 11M, 11.5M, 12M, 12.5M and 13M molarity) of M-30 grade geopolymer concrete

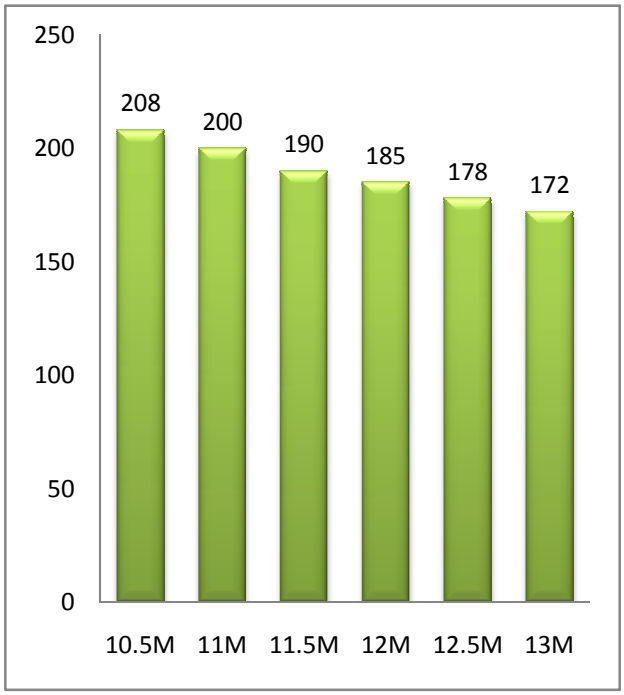

Fig. 3. Slump Values for Different molarity of M-30 grade geopolymer concrete.

(ii) Compressive strength results: On the basis of the different molarity of NaOH. In this study we use 10M, 10.5M, 11M, 11.5M, 12M, 12.5M and 13M than results are shown in ambient and heat curing at 60°C for M-30 grade concrete

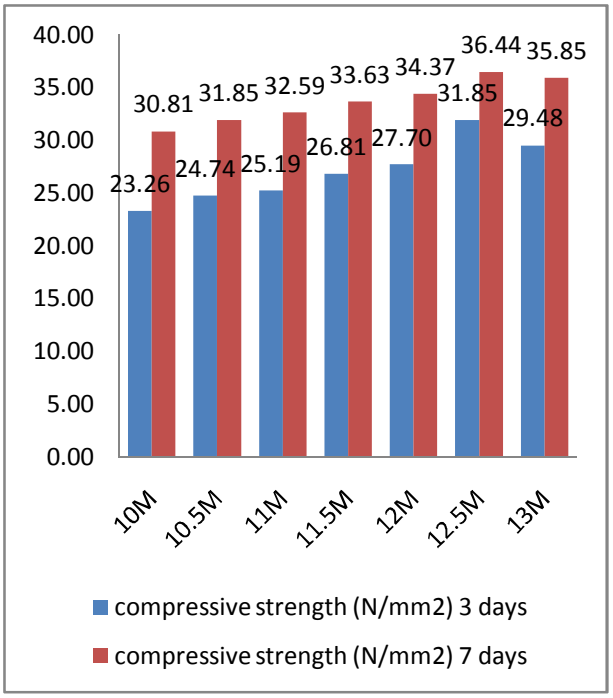

Fig. 4. Compressive strength different molarity at ambient temperature of M-30 grade geopolymer concrete.

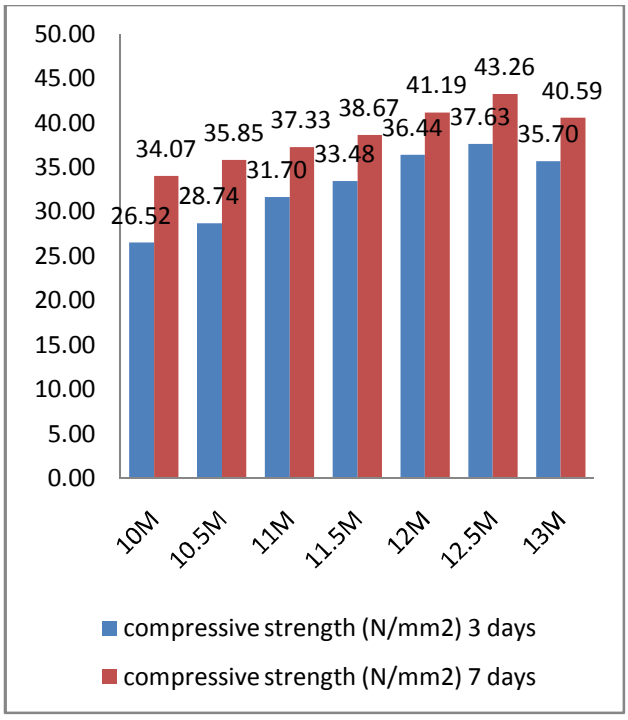

Fig. 5. Compressive strength different molarity at 60℃ temperature of M-30 grade geopolymer concrete.

(iii) Flexural strength results: On the basis of the different molarity of NaOH. In this study we use 10M, 10.5M, 11M, 11.5M, 12M, 12.5M and 13M than results are shown in ambient and heat curing at 60°C for M-30 grade concrete

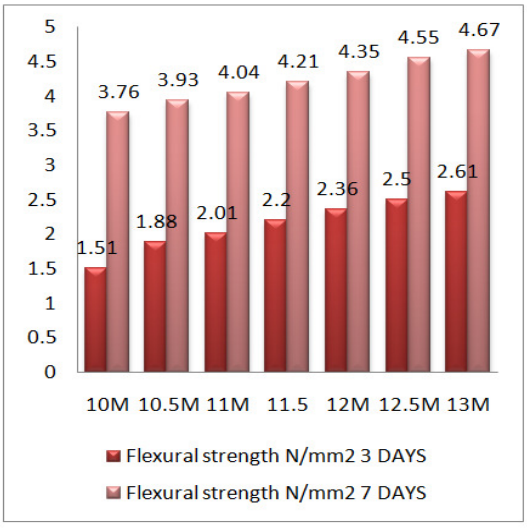

Fig. 6. Flexural strength different molarity at ambient temperature of M-30 grade geopolymer concrete.

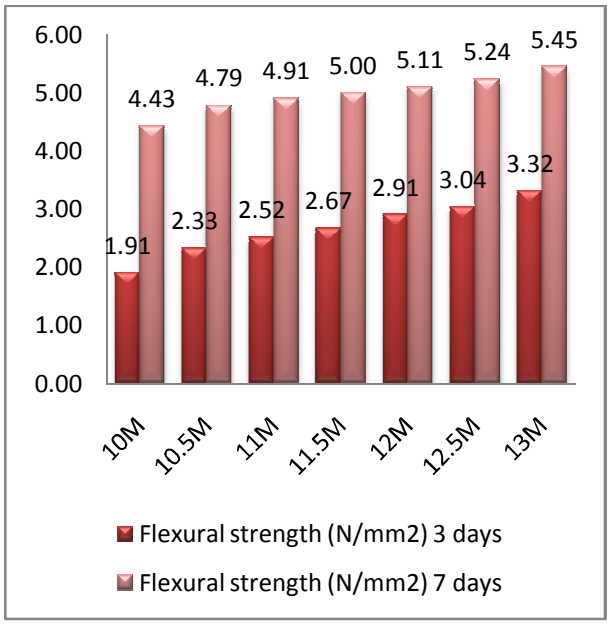

Fig. 7. Flexural strength different molarity at 60℃ temperature of M-30 grade geopolymer concrete.

V. CONCLUSION

Based on above result following conclusion are:

1. Slump value of geo-polymer concrete tends to decrease with increase in molarity. Through slump value of geopolymer concrete further decreases with increase in molarity with 10M to 13M in geopolymer concrete. At 13 M use in geopolymer 14.00 % decrement was observed.
2. The 7th day compressive strength of the concrete for the mix of 10 M to 12.5M was observed to be in the range of 30.81 MPa to 38.85 MPa for specimen cured at ambient temperature, whereas the strength varied between 34.07 MPa to 40.59 MPa for specimen cured at 60℃.

3. The 7th day Flexural strength of the concrete for the mix of 10 M to 12.5M was observed to be in the range of 3.76 MPa to 4.67 MPa for specimen cured at ambient temperature , whereas the strength varied between 4.43 MPa to 5.45 MPa for specimen cured at 60^{o}C.
4. As compare to Conventional concrete to geopolymer concrete compressive strength is high but flexural strength is low.

VI. FUTURE SCOPE

As it is a new type of concrete, a new technology with its various benefits and profits, it has tremendous future scope. Some of those are listed below.
i. Extensive research can be carried out in geopolymer concrete.
ii. Effect on its alkalinity on corrosion of steel can be studied.
iii. High strength concrete can be achieved by using geopolymer binder
iv. Self-compacting concrete can be made using different mineral and chemical admixtures in geopolymer concrete.
v. More innovative and new technology research can be carried out by deeply studying geopolymer chemistry.

REFERENCES

[1]. Ranjan, B. V. (2014). Geopolymer construction for Environmental Protection. *Indian Concrete Journal*.
[2]. Fernández-Jiménez, A., & Palomo, A. (2003). Characterisation of fly ashes. Potential reactivity as alkaline cements. *Fuel, 82*(18), 2259-2265.
[3]. Hardjito, D., & Rangan, B. V. (2005). Development and properties of low-calcium fly ash-based geopolymer concrete.
[4]. Hardjito, D., Wallah, S. E., Sumajouw, D. M. J., & Rangan, B. V. (2005, August). Introducing fly ash-based geopolymer concrete: manufacture and engineering properties. In 30th conference on our world in concrete & structures.
[5]. Hardjito, D., Wallah, S. E., Sumajouw, D. M., & Rangan, B. V. (2004). On the development of fly ash-based geopolymer concrete. *Materials Journal, 101*(6), 467-472.
[6]. IS 2386-1:1963, "Method of Test on Concrete Aggregate Part 1 – Particle Size and Shape", Bureau of Indian Standards, New Delhi.
[7]. IS 2386-2:1963, "Method of Test on Concrete Aggregate Part 1 – Estimation of Deleterious Material and other Organic Impurities", Bureau of Indian Standards, New Delhi.
[8]. IS 2386-3:1963, "Method of Test on Concrete Aggregate Part 1 – specific gravity, voids, absorption and bulking", Bureau of Indian Standards, New Delhi.
[9]. Davidovits, J. (2013). Geopolymer cement. A review. Geopolymer Institute, *Technical papers, 21*, 1-11.
[10]. Neville, A. M. (2000). Properties of Concrete (Fourth and Final ed.). Essex, England.
[11]. Palomo, A., Fernandez-Jimenez, A., Lopez-Hombrados, C., & Lleyda, J. L. (2004). Precast elements made of alkali-activated fly ash concrete. In International Conference on fly ash, silica fume, slag and natural pozzolans in concrete. USA.
[12]. Patankar, S. V., Ghugal, Y. M., & Jamkar, S. S. (2014). Effect of concentration of sodium hydroxide and degree of heat curing on fly ash-based geopolymer mortar. *Indian Journal of Materials Science*.
[13]. Patankar, S. V., Jamkar, S. S., & Ghugal, Y. M. (2014). Selection of suitable quantity of water, degree and duration of heat curing for geopolymer concrete production. In Proceedings of *3rd International Conference on Recent Trends in Engineering & Technology (ICRTET'2014*), 1-4.
[14]. Rangan, B. V., Sumajouw, D., Wallah, S., & Hardjito, D. (2006, August). Reinforced low-calcium fly ash-based geopolymer concrete beams and columns. In *31st Conference on our world in concrete & structures,* 16-17.
[15]. Duxson, P., Provis, J. L., Lukey, G. C., & Van Deventer, J. S. (2007). The role of inorganic polymer technology in the development of 'green concrete'. *Cement and concrete research, 37*(12), 1590-1597.
[16]. Sofi, M., Van Deventer, J. S. J., Mendis, P. A., & Lukey, G. C. (2007). Engineering properties of inorganic polymer concretes (IPCs). *Cement and Concrete Research, 37*(2), 251-257.
[17]. Sumajouw, M., & Rangan, B. V. (2006). Low-calcium fly ash-based geopolymer concrete: reinforced beams and columns (Research Report GC3–Faculty of Engineering). Perth, Australia: Curtin Univ. of Technology.
[18]. Wallah, S. E., & Rangan, B. V. (2006). Low-Calcium Fly Ash-Based Geopolymer Concrete: Long-Term Properties. Faculty of Engineering, Curtin University of Technology; Perth. Australia: 2006. Research Report GC-2.

How to cite this article: Palash, P. S. and Dhurvey, P. (2020). Performance Evaluation of Geopolymer Concrete as Green Construction Material. *International Journal on Emerging Technologies, 11*(4): 393–396.