



# Mechanical Properties of OPC - Geocement Concrete

P.Dinesh kumar, T.Jeevetha, K.NirmaKumar, N.Nandhini, S.Vijayashanthy

**Abstract:** Nowadays geopolymers are subjected to heat curing. A large amount of highly corrosive and the hygroscopic alkaline activators are nowadays generally utilized in producing geopolymer concretes. In this paper, hybrid Ordinary Portland Cement (OPC) and geopolymer mixes are developed. The mainly used activator is the Solid potassium carbonate at different percentage is used as 5% & 10% of the weight of geopolymeric materials and OPC was blended with geopolymeric materials in different proportions. By adding cement, improves all the geopolymer properties except workability. By applying external heat, it plays an important role in gaining strength. Strength gained by the absence of external heat is achieved by using Portland cement as a partial replacement of geocement. The influence of OPC content on the compressive strength development is investigated, and the optimized amount of solid activator to be used in the mix is also investigated. It is observed that percentage of strength increase decreases from 52.24% to 14.77% as the OPC content increased from 20% to 60%.

**Keywords :** activator, external heat, heat curing, potassium carbonate.

## I. INTRODUCTION

Concrete is widely used in construction of buildings, bridges and other structures, it consumes natural resource like lime, aggregate, water, etc. Since cement is a major component of concrete, which has its own environmental and social impacts. The worldwide production of cement has greatly enlarged and its production outcome in a lot of environmental pollution as it requires the emission of CO<sub>2</sub> gas. In this paper geo-cement is blended with conventional ordinary Portland cement. The blending of OPC and geo-cement leads to more compact and less porous structure. These impact of concrete, its manufacture and applications, are complex in the environment. Some effects are harmful. The carbon dioxide emission are higher particularly in cement industries. Extracting one tonne of cement requires about two

tonnes of raw materials and releases 0.87 tonne of CO<sub>2</sub>. Cement industry is responsible for 5% global carbon dioxide emission. To reduce this carbon dioxide emission geocement can be used instead of ordinary portland cement or it can be blended with OPC. This geocement usually consists of flyash, bottom ash and slag, which are the by-products of other industries that would differently end up in landfills. Geocement is a pledge to reduce global warming by reducing carbon dioxide emission using a proprietary liquid geo-binder with various industrial by-products viz. Fly ash, blast furnace slag etc. Geopowder thus making it an environmental friendly green Product. The carbon dioxide emission and dumping of industrial in uncontrolled manner should be stopped to prevent the environment. Using OPC in geocement concrete up to 15% increases the compressive, tensile strength and also the modulus of elasticity but the workability with increase in Portland cement gets decreases. Raising curing period even with low curing temperature improves the strength properties[1]. The type activator has also some influence on the strength of the concrete. with varying the percentage of activator there is also a change in strength of the concrete[2]. With the absence of external heat enhances the early compressive strength as well as final compressive strength[3]. Calcium content plays a major role in geopolymerization of blended geopolymer samples[4]. Al rich mineral admixtures are incorporated and cured at elevated temperature will help in reducing the efflorescence[7]. Various waste management problems can be reduced by utilizing the geopolymers derived from industrial byproducts [8]. Size of the aggregate plays a role in strength properties at both ambient and elevated temperature. the strength loss is due to thermal mismatch between geopolymer matrix and the aggregate[9]. The calcium based products formed by the hydration mechanism leads to the increase in strength of the concrete[11].

## II. LITERATURE STUDY

Askarian et al., (2018) have investigated on the mechanical properties of ambient cured one-part hybrid OPC-geopolymer concrete. In this study one-part hybrid OPC-geopolymer concrete were developed in which solid potassium carbonate was used as the main activator. The influence of OPC content on the workability, setting time, compressive strength development and microstructure of the concrete was investigated. Setting time and the workability of concrete mix is reduced when the OPC is mixed with geopolymer mix and at the same time early age and ultimate compressive strength is increased due to the quick reaction of OPC with alkaline activators. Micro structural analysis confirmed the coexistence of geopolymeric and CSH gels in the one-part hybrid OPC-geopolymer binder system.

Manuscript published on November 30, 2019.

\* Correspondence Author

**P.Dinesh kumar\***, Civil Engineering, Kongu Engineering College, Erode, Tamil Nadu, India.

**T.Jeevetha**, Civil Engineering, Kongu Engineering College, Erode, Tamil Nadu, India.

**K.NirmalKumar**, Civil Engineering, Kongu Engineering College, Erode, Tamil Nadu, India.

**N.Nandhini**, Civil Engineering, Kongu Engineering College, Erode, Tamil Nadu, India.

**VijayaShanthy.S**, Civil Engineering, Kongu Engineering College, Erode, Tamil Nadu, India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license <http://creativecommons.org/licenses/by-nc-nd/4.0/>

Mehta et al., (2017) have suggested on properties of low calcium flyash based geopolymer concrete incorporating OPC as partial replacement of flyash. Compressive strength, Water absorption, porosity, sorptivity, and chloride permeability were studied.

SEM and XRD analysis were also conducted. From micro structural analysis the voids and micro cracks are reduced by the addition of OPC comparing to OPC free geopolymer concrete. Resistance to chloride ions has been increased with the addition of OPC in geopolymer concrete.

Hajimohammadi et al., (2017) have done research on characterization of one-part geopolymer binders made from flyash. In this research geopolymerization reaction is studied in the system of flyash as an aluminosilicate precursor and solid sodium silicate as alkali activator. Their participation in geopolymer structure is affected by the release of Si and Al from source materials. The crystalline phases that usually appear in geopolymer are missing in one part mixes are studied here. Adjusting the composition of raw materials can improve the mechanical properties of one part geopolymer mix binder.

Luukkonen et al., (2017) have reported that to limit CO<sub>2</sub> emissions as well as to benefit some waste into useful products, ordinary portland cement can be replaced by alkali-activated materials. However, the alkali activation involves concentrated aqueous alkali solutions, which are corrosive, viscous and not user friendly. Consequently the development of one-part alkali activated materials have greater potential than the conventional two part alkali activated materials.

Shehab et al., (2016) have reported the mechanical properties of flyash based geopolymer concrete with full and partial cement replacement. This research is done to reduce the carbon dioxide emission and to make alternate environment friendly concrete called geopolymer which is an inorganic alumina silicate mineral, synthesized from flyash which is rich in silicon and aluminium. Replacement of flyash based geopolymer improved the mechanical properties of concrete. Compressive strength, Split tensile strength and flexural strength are higher for 50% replacement compared to other proportions.

Assi et al., (2016) have conducted research on the improvement of the early and final compressive strength of flyash based geopolymer concrete at ambient conditions. The effect of sodium hydroxide ratio, external heat amount, and partial portland cement replacement on flyash based geopolymer concrete were investigated. Experiment showed that application of external heat plays a major role in compressive strength. This study shows that the initial and final compressive strength gains, in lacking of external heat, can be better by using portland cement as a partial replacement of fly ash.

Aliabdo et al., (2016) have studied the effect of cement addition, solution resting time and curing feature on fly ash based geopolymer concrete performance. Before and after casting of geopolymer concrete, specimen needs several approaches. Development of geopolymer concrete become a necessity to widen its applications beyond precast structures. The study results shows that generally adding cement improves all fly ash based properties except workability. The increase of fly ash content boost geopolymer properties. Geopolymer concrete properties crucially affected by curing approaches which are represented in curing time and temperature.

### III. EXPERIMENTAL PROCEDURE

#### A. Materials

In this study, Ordinary Portland Cement (OPC) of 53 Grade conforming to the specifications IS: 12269–1987 is used. The geocement which consists of flyash(40%) and GGBS(60%) with specific gravity 2.15 is used. Coarse aggregate of size 20mm is used and the fine aggregate (M- sand) of size 4.75 μm is used and the properties of the aggregates are shown in Table I. The solid activator used in this study is Potassium carbonate with 99.99% purity in powder form.

**Table- I: Properties of Aggregates**

S.No	Property	Coarse aggregate	Fine aggregate
1	Fineness modulus	7.36	2.75
2	Specific gravity	2.74	2.57
3	Water absorption	0.83	2.26
4	Maximum Size	20 mm	4.75 μm

#### B. Concrete Mix Proportion and Specimen Preparation

The mix proportions of hybrid OPC - geopolymer mixes are shown in Table II. Mixes were prepared by varying the proportions of OPC and geocement. Solid activator at 5% and 10% weight of geopolymeric material was used. Ingredients include OPC, geocement, solid activator, coarse aggregate and sand were mixed thoroughly before adding water. Then water and super plasticizer were added gradually. The freshly mixed concrete was casted in cube mould of size 150\*150\*150mm. Then the samples were demoulded after 24hours and then allowed for ambient curing.

**Table- II: Mix Proportions of One Part Geopolymer Concrete**

Materials Required (1 Cube)	% of Replacement			
	M-1 (0%)	M-2 (20%)	M-3 (40%)	M-4 (60%)
Geocement (Kg)	1.329	1.063	0.797	0.531
Cement(Kg)	0	0.265	0.531	0.797
Fine Aggregate(Kg)	2.152	2.152	2.152	2.152
Coarse Aggregate(Kg)	3.743	3.743	3.743	3.743
Water (lit)	0.531	0.531	0.531	0.531
Activator (Kg)	5%	0.066	0.053	0.039
	10%	0.1329	0.106	0.079

#### C. Testing Procedure

Compressive strength is the ability of the material to carry the load on its surface without any crack or deflection. After 28 days of curing compressive strength of the concrete is tested. Load is applied on the specimens at the rate of 140Kg/cm<sup>2</sup> until the specimen fails.

Compressive strength of the concrete is equal to the load at the failure divided by the area of the specimen. The specimens with various cement proportions and activator percentage are labeled as given in Table III.

**Table- III: Labeling of Specimen**

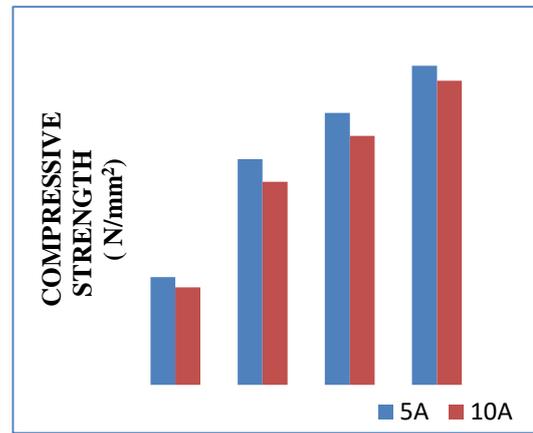
S.No	Description	Label of Specimen
1	Concrete with 100% Geocement 0% OPC and 5% activator	GP0-5A
2	Concrete with 80% Geocement 20% OPC and 5% activator	GP20-5A
3	Concrete with 60% Geocement 40% OPC and 5% activator	GP40-5A
4	Concrete with 40% Geocement 60% OPC and 5% activator	GP60-5A
5	Concrete with 100% Geocement 0% OPC and 10% activator	GP0-10A
6	Concrete with 80% Geocement 20% OPC and 10% activator	GP20-10A
7	Concrete with 60% Geocement 40% OPC and 10% activator	GP40-10A
8	Concrete with 40% Geocement 60% OPC and 10% activator	GP60-10A

**IV. RESULTS AND DISCUSSIONS**

The compressive strength of the concrete at 28days are shown in Table IV. The specimen GP0-10A has achieved very less compressive strength of about 12.3 MPa. The specimen GP60- 5A attained the maximum compressive strength which shows increasing the percentage of OPC Compressive strength of the concrete has increased. The collation of compressive strength of two different percentages of activators are shown in Figure I. In hybrid OPC geo polymer mixes the alkali activation helps in achieving the strength of the concrete. The hardening of mixes is also due to the alkaline activator and OPC reaction. The alkali activation is also accelerated by the heat of hydration of OPC which results in the increase in the strength of the concrete.

**Table- III: Labeling of Specimen**

SPECIMEN TYPE	AVERAGE COMPRESSIVE STRENGTH(N/mm <sup>2</sup> )
GP0-5A	13.6
GP20-5A	28.48
GP40-5A	34.31
GP60-5A	40.26
GP0-10A	12.3
GP20-10A	25.6
GP40-10A	31.4
GP60-10A	38.37



**Fig 1: Compressive strength of specimens**

**V. CONCLUSIONS**

- The Compressive strength of the concrete at heterogeneous proportions of OPC and geo-cement is determined.
- Optimized amount of activator to be used in the mix is evaluated.
- From the experimental investigation it is observed that mix of 60% OPC and 40% geo-cement with 5% activator obtains the maximum strength of 40.26MPa.
- It is observed that percentage of strength increase decreases from 52.24% to 14.77% as the OPC content increased from 20% to 60%.

**REFERENCES**

1. Aliabdo, A., Elmoaty, A.E.M.A., Salem,H.A., (2016), "Effect of cement addition , solution resting time and curing characteristics on fly ash based geopolymer concrete performance", Construction building materials, Vol.123, pp.581-593.
2. Askarian, Tao, Adam, Samali, (2018), "Mechanical properties of ambient cured one - part OPC geopolymer concrete", Construction and Building Materials, Vol.186, pp.330-337.
3. Assi, Ghahari, Deaver, Leaphart, Ziehl, PE, (2016), "Improvement of the early and final compressive strength of fly ash based geopolymer concrete at ambient conditions", Construction and Building Materials, Vol. 123, pp.806-813.
4. Canfield, M., Eichler, Griffith, Hearn, D.,(2014), " The role of calcium in blended fly ash geopolymers", Journal of material sciences, Vol.49, No.17, pp.5922-5933.
5. Hajimohammadi, Jannie, S.J., Deventer, (2017), "characterization of one - part geopolymer binders made from fly ash", Waste Biomass Valor, Vol. 8, pp.225-233, DOI: 10.10007/s12649-016-9582-5
6. Hajimohammadi, Jannie, S.J., Deventer, (2011), "The effect of silica availability on the mechanism of geopolymerisation", Cement and concrete research, Vol.41, No.3, pp.210-216.
7. Kani, Allahverdi, Provis, L., (2012), "Efflorescence control in geopolymer binders based on natural pozzalona", Cement and Concrete Composites, Vol.34,No.1, pp.25-33.
8. Ken, Ramli, Ban, (2015)," An overview on the influence of various factors on the properties of geopolymer concrete derived from industrial by products", Construction and building materials", Vol.77, DOI: 10.1016/j.conbuildmat.2014.12.065.
9. Kong, L.Y., Sanjayan, G., (2010), " Effect of elevated temperature on geopolymer paste, mortar and concrete", Cement and Concrete Research, Vol. 40, No.2, pp.334-339.

## Mechanical Properties of OPC - Geocement Concrete

10. Luukkonen, Abdollahnejad, Yliniemi, Illikainen, (2017), " One - part alkali - activated materials: A review ", Cement and concrete Research, Vol.82, DOI: 10.1016/j.cemconres.2017.10.001.
11. Mehta, Siddique, (2017), "Properties of low calcium fly ash based geopolymer concrete incorporating OPC as partial replacement of fly ash", Construction and building materials, Vol.150, pp.792-807.
12. Nath,P., Sarker,P.K., (2015), "Use of OPC to improve setting and early strength properties of low calcium fly ash geopolymer concrete cured at room temperature", Cement and concrete composites, Vol.55, pp.205-214.
13. Nematollahi, Sanjayan, Shaikh, (2014), "Synthesis of heat and ambient cured one - part geopolymer mixes with different grades of sodium silicate", Ceramics international, DOI: <http://dx.doi.org/10.1016/j.ceramint.2014.12.154>
14. Shehab, K. Eisa, S. Wahba, M. (2016), "Mechanical properties of fly ash based geopolymer concrete with full and partial cement replacement", Construction and Building Materials, Vol.126, pp.560-565.
15. Singh,B., Ishwarya,G., Gupta,M., Bhattacharyya,S.K., (2015), "Geopolymer concrete: A review of some recent developments", Construction and building materials, Vol.85, pp.78-90.
16. Suwan,T. and Fan,M., (2014), "Influence of OPC replacement and manufacturing procedures on the properties of self cured geopolymer", Construction and building materials, Vol.73, pp.551-561.

### AUTHORS PROFILE



**Mr.P.Dinesh kumar** has completed her BE degree in Civil Engineering, ME degree in Structural Engineering and published 4 International Journals, 6 National Conferences and currently pursuing his PhD degree.



**Ms. T.Jeevetha** has completed her BE degree in Civil Engineering, ME degree in Structural Engineering and published 2 International Journals, 2 National Conferences and currently pursuing her PhD degree.



**Dr.K Nirmalkumar** has completed her BE degree in Civil Engineering, ME degree in Structural Engineering and completed Ph.D in the year 2009. Also published 44 International Journals, 40 National Conferences.



**.Ms. Vijayashanthi.S** has completed her UG degree in civil Engineering, PG degree in Environmental Engineering and published papers in 1 International Journal, 9 International Conferences, 4 National Conferences & currently pursuing her PhD degree



**Mrs.N.Nandhini** has completed her M.E degree in Construction Engineering and Management doing PhD in Construction Engineering. Published papers in 1 National Conference, 8 international Conferences & 16 International Journals.