International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 02 | Feb-2018 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL INVESTIGATION OF GEOPOLYMER CONCRETE WITH STEEL FIBERS UNDER DIFFERENT CURING EXPOSURES

J.S.Kishore Kumar [1], B.PRABU [2], A.SHALINI [3]

[1]*Assistant Professor, Department of Civil Engineering , Dhirajlal Gandhi College of Technology,Salem*
[2]*Assistant Professor, Department of Civil Engineering , V S A Group of Institutions,Salem*
[3]*Assistant Professor, Department of Civil Engineering , Sona College of Technology, Salem*

Abstract - *Concrete is the most used construction material from ancient days. It was expected that the production of cement would be increased from about from 1.5 billion tons in 1995 to 2.2 billion tons in 2020. The cement production contributes nearly 7% of worlds global warming due to emission of greenhouse gases, such as CO_2, to the atmosphere. Hence, it is essential to find an substitute material for cement. The technology geopolymer concrete found as alternative for this problem. In this present research, cement is replaced with Fly Ash and GGBS in different percentages with steel fibers. The concentration of NaOH was kept as 12M.The fresh and hardened properties of geopolymer concrete were found with and without steel fiber. The specimens were cast and cured in controlled room temperature and heat curing. The test results of room cured specimens were compared with heat cured specimens.*

Key Words*: *Global Warming, Polymerization, Alkaline solution, Curing, Strength.

1.INTRODUCTION

The term geopolymer was first coined by chemistry professor Davidovits in 1978 to describe a family of mineral binders with chemical composition to similar that of zeolites but with an amorphous microstructure. Geopolymer concrete does not require any water for matrix bonding. Instead, the alkaline solution reacts with Silicon and Aluminium present in the fly ash. Geopolymer was synthesized by mixing alumina silicate-reactive material with robust alkali solutions, such as sodium hydroxide (NaOH), potassium hydroxide

(KOH), sodium silicate or potassium silicate [1]. The effect of class F fly ash (FA) and ground granulated blast furnace slag (GGBS) on the mechanical properties of geopolymer concrete (GPC) at different replacement levels are made to obtain the optimum percentage [2]. The polymerization process was accelerated in the higher temperature than ambient. Fly ash-based geopolymer concrete cured in ambient temperature achieves lower strength in the early days as compared to heat cured samples but in ambient curing the compressive strength increases as the age of concrete increases from 7 days to 28 days [3]. Ambient curing condition is most realistic and economic curing condition in the temperature range of 25-45 degree centigrade. Oven dried curing condition is controlled hot air curing at a particular temperature for required duration, which substantially improves the strength of concrete as compared to ambient curing condition[4]. It was observed that 90% of strength achieved within seven days and there is not much variation in strength After seven days under heat cured conditions. It is observed that the strength development of Geopolymer concrete is slow under ambient conditions and 100% strength achieved at 28 days only [5]. It was shown that heat-cured geopolymer concrete possesses the properties of high compressive strength, low drying shrinkage and creep, and excellent resistance to sulphate and acid [6].

2.Research Objective:

The objective of this research is to study the performance of geopolymer concrete without and with steel fibers under different curing. The speciemns are cast with the following proportions of pozzalonic materials :

Geopolymer concrete with 100% of Fly Ash, 90% of Fly Ash and 10% of GGBS and 90% of Fly Ash and 10% of GGBS with Steel fibres in different volume fractions. The specimens were cured in room temperature and heat. The hardened properties such as compressive, tensile and flexural strength were tested at the age of 7 and 28 days. The result obtained from various curing conditions to be compared.

3.Experimental Programme:

a) Materials

1. Fly Ash with low calcium content obtained from Mettur thermal power plant
2. Ground Granulated Blast Furnace Slag with specific gravity of 2.72 was used.
3. Locally available river sand conforming to the grading of Zone III of IS: 383-1970 with specific gravity 2.48 and fineness modulus as 2.61 fine aggregates (FA) was used.
4. Crushed blue granite stones aggregate of the maximum size of 12 mm and graded as per IS: 383-1970 with specific gravity 2.68 and fineness modulus was used as coarse aggregate (CA).
5. Distilled water was used for the preparation of sodium hydroxide solution. Conplast SP 435

Superplasticizer is also used to increase the workability of concrete.

6. Hooked end steel fibers are used. Table 1 presents the properties of steel fibers.

Table 1: Properties of Steel Fibres

S.No	Properties	Description
1	Type	Hook End
2	Length	35mm
3	Diameter	0.75mm
4	Aspect Ratio	45

b) Mix Proportions:

The density of geopolymer concrete was assumed as 2400kg/m3 as similar to conventional concrete. The total volume occupied by coarse and fine aggregate is taken as 77-80%.

The various limitations used in this research are given below:

1. The alkaline liquid to fly ash ratio was taken as 0.4.
2. The ratio of sodium silicate to sodium hydroxide is kept as 2.5.
3. Extra water taken as 15% of the cementitious material.
4. Super Plasticizer taken as 3% of cementitious material.

The molarity of NaOH was 12.

Different volume fractions of fibers were adopted in concrete mix as described in Table 2.

Table 2: Different Volume Fraction of Fibres

S.No	Specimen ID	Steel Fibre (%)
1	F100	0
2	F90G10	0
3	F90G10 AR 0.25%	0.25
4	F90G10 AR 0.50%	0.5
5	F90G10 AR 0.75%	0.75

Table 3 presents the material required for one-meter cube of concrete without and with steel fibers.

Table 3: Material required for one-meter cube of Concrete

S.No	Material (kg/m³)	F_{100}	$F_{90}G_{10}$	F90G10 AR 0.25%	F90G10 AR 0.50%	F90G10 AR 0.75%
1	Fly Ash	394	354.87	354.87	354.87	354.87
2	GGBS	-	39.43	39.43	39.43	39.43
3	FA	554	554.4	554.4	554.4	554.4
4	CA	1293	1293.4	1293.4	1293.4	1293.4
5	NaOH	45.1	45.1	45.1	45.1	45.1
6	Na_2SiO_2	113	112.6	112.6	112.6	112.6
7	Water	59.1	59.14	59.14	59.14	59.14
8	SP	11.8	59.14	59.14	59.14	59.14
9	Steel fibers	-	-	19.63	39.25	58.88

c) Casting of Specimens

The cube of size 100mm X 100mm X100mm was cast. The cylinder of size 150 mm diameter and 300 mm height were cast to find tensile strength. The prism of size 100mm x 100m x 500mm were cast to find flexural strength. The fresh concrete was filled in the steel moulds in three equal layers, and each layer was well compacted using table vibrator to prevent the pores in the concrete.

Fig. 1 Specimen Casting

d) Curing Of Specimens

The cast specimens are de-moulded after 24 hours. After that specimens are kept in a hot air oven for 24 hours at 60oC for heat curing and specimens kept in room temperature for ambient curing.

Fig .2 Hot Air Oven

The specimens in hot air oven and ambient curing are shown in Fig. 2 and Fig.3.

Fig .3 ambient curing

e) Testing of Specimens

The compressive strength determination was the primary objective. The cube specimens of 100 mm size were tested at the age 7 days and 28 days. The results were compared with heat curing and ambient curing.

Fig.4 Compression test setup

4. Result and Discussions:

The experimental results obtained from ambient curing exhibits that the compressive strength increases with the addition of steel fibers with different dosages. At 7 days the compressive strength of geopolymer concrete with 0.25% is of steel fibers increased 2.08 times compared F100 geopolymer concrete. Similarly the compressive strength of geopolymer concrete with 0.5% and 0.75% of steel fibers increased by 2.21 and 2.43 times compared to F100 geopolymer concrete. At 28 days the compressive strength of geopolymer concrete with 0.25 %, 0.5% and 0.75 % of steel fibers increased by 2.05, 2.17 and 2.36 times compared to F100 geopolymer concrete.

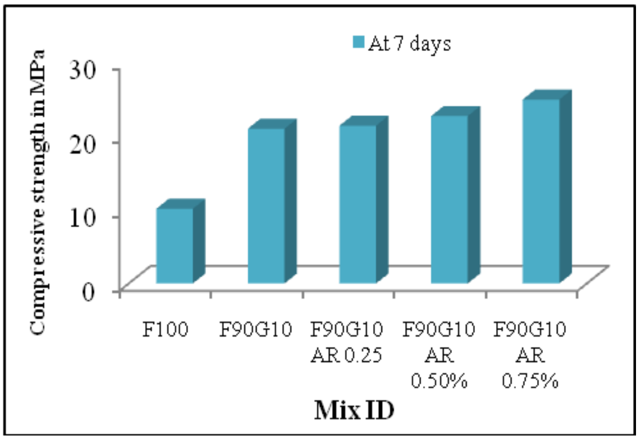


Fig 5 Compressive strength at 7 days

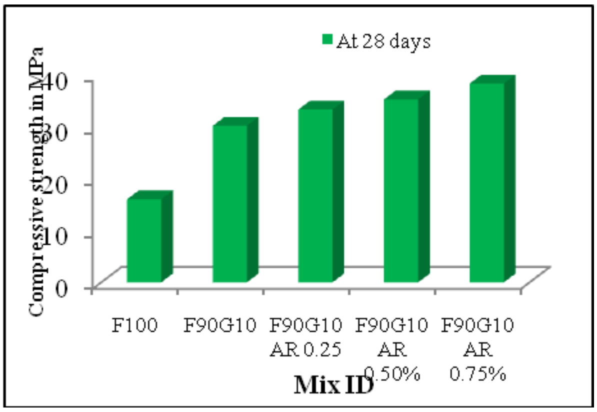
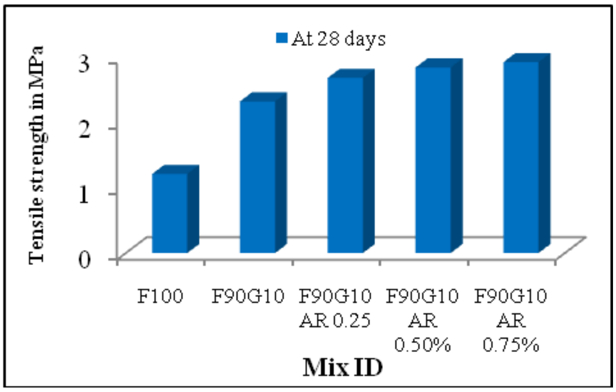


Fig 6 Compressive strength at 28 days

The split tensile strength of geopolymer concrete with 0.25%, 0.5% and 0.75% increased by 2.21, 2.35 and 2.41 times compared to F100 geopolymer concrete.



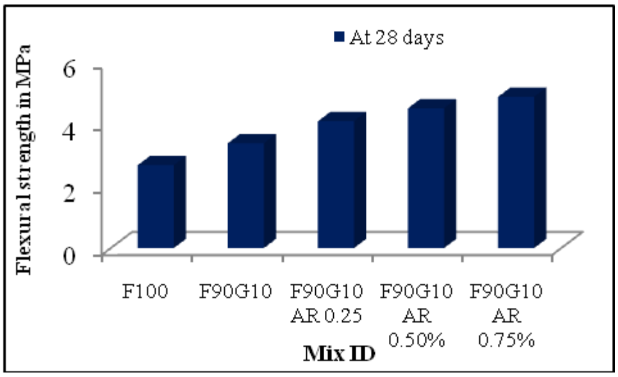


Fig 7 and Fig 8 Split Tensile and Flexural strength at 28 days

The flexural strength of geopolymer concrete with 0.25%, 0.5% and 0.75% enhanced by 1.53, 1.69 and 1.82 times compared to F100 geopolymer concrete.

The experimental results obtained from ambient curing exhibits that the compressive strength increases with the addition of steel fibers with different dosages. At 7 days the compressive strength of geopolymer concrete with The geopolymer concrete without steel fibers under heat curing at seven days is 308 times better than ambient curing.

Similarly, the geopolymer concrete without steel fibers under heat curing at 28 days is 2.08 times better than ambient curing The geopolymer concrete with steel fibers of 0.25%, 0.5% and 0.75% under heat curing at seven days is 1.61, 1.66 and 1.60 times better than ambient curing. Similarly, the geopolymer concrete with steel fibers of 0.25%, 0.5% and 0.75% under heat curing at 28 days is 1.01, 1.10 and 1.07 are better than ambient curing.

The compressive, split tensile, flexural strength for different mix proportions as shown in Fig 5, Fig 6, Fig 7 and Fig 8.

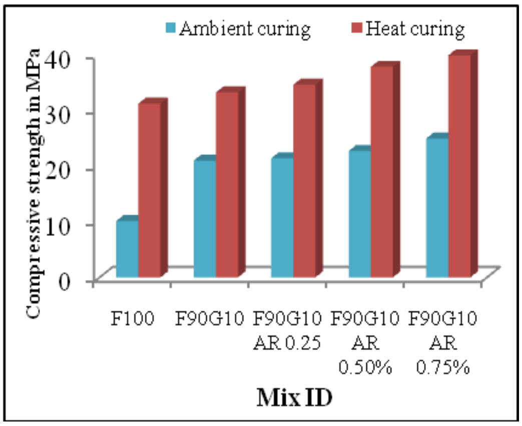


Fig 9 Comparison between ambient curing and Heat curing at 7 days

The comparison is done between ambient curing and heats curing of geopolymer concrete for geopolymer concrete with and without steel fibers were shown Fig. 9 and Fig 10.

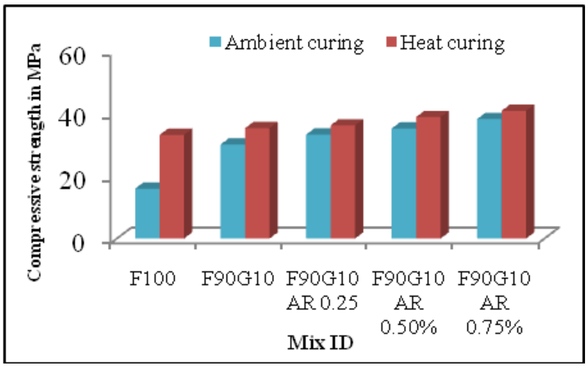


Fig 10 Comparison between ambient curing and Heat curing at 28 days

5. CONCLUSIONS

From the experimental results, the following conclusion was drawn.

1. Compared to F100 GPC, FRGPC yields better mechanical properties.
2. At the age of 7 and 28 days, the compressive strength of FRGPC gives better results due to addition of steel fibers. It arrests the initial crack and makes the concrete to sustain more loads.
3. When compared to the flexural behavior, split tensile and compressive strength of Fibre Reinforced Geopolymer concretes with Geopolymer concretes, the Fibre Reinforced Geopolymer concrete possess good ductile in nature.
4. The comparison is done between heat curing and ambient curing .
5. From this, the compressive strength of GPC and FRGPC under heat curing at 7 days possesses better results than ambient curing.
6. At later age such that at 28 days ambient curing possesses superior results than heat curing.

REFERENCES

[1] S. E. Wallah and B. V. Rangan "Low-calcium fly ash-based Geopolymer concrete: long-term Properties," Research Report GC 2 Faculty of Engineering Curtin University of Technology Perth, Australia 2006.

[2] B. Rajini, A.V. Narasimha Rao "Mechanical Properties of Geopolymer concrete with Fly Ash and GGBS as Source material," International Journal of Innovative Research in Science, Engineering and Technology, ISSN: 2319-8753, Vol. 3, Issue 9, September 2014.

[3] A.R.Krishnaraja, N.P.Sathishkumar, T.Sathish Kumar, P.Dinesh Kumar "Mechanical Behaviour of Geopolymer Concrete under Ambient Curing," International Journal of Science , Engineering and Technology,ISSN : 2277-1581, Volume No.3 Issue No.2, pp : 130 – 132, 1 Feb 2014.

[4] S. V. Joshi and M. S. Kadu " Role Of Alkaline Activator in Development of Eco- friendly Fly Ash-based Geopolymer Concrete," International Journal of Environmental Science and Development, Vol. 3, No. 5, October 2012

[5] Kolli Ramujee, M. Potharaju " Development of Low calcium Fly Ash-based Geopolymer Concrete," IACSIT International Journal of Engineering and Technology, Vol. 6, No. 1, February 2014.

[6] Deepa Raj S. and Ruby Abraham Ganesan, Divya Sasi (2013) " Fracture properties of fiber reinforced geopolymer concrete." International Journal of Scientific & Engineering Research Volume 4, Issue 5, May- 2013 ISSN 2229-5518.

[7] Faiz Uddin and Ahmed Shaikh (2012) "Review of mechanical properties of short fiber reinforced

geopolymer composites." Construction and Building Materials.

[8] N. Ganesan, P.V. Indira and Anjana Santha Kumar (2013) "Engineering properties of steel fiber reinforced geopolymer concrete." Advances in Concrete Construction.

[9] S. Kumaravel(2014)"Development of various curing effect of nominal strength Geopolymer concrete." Journal of Engineering Science and Technology.

[10] A.R.Krishnaraja N.P.Sathishkumar, T.Sathish Kumar, P.Dinesh Kumar (2014) "Mechanical Behaviour of Geopolymer Concrete under Ambient Curing." International Journal of Scientific Engineering and Technology ISSN : 2277-1581.

[11] Lloyd N and Rangan V (2009) "Geopolymer concrete-sustainable cementless concrete."

[12] A.Maria Rajesh, M.Adams Joe, Roy Mammen (2014) "Study of the strength geopolymer concrete with an alkaline solution of varying molarity."IOSR Journal of Engineering (IOSRJEN) ISSN : 2250-3021

[13] A. Maria Rajesh et al. (2014) "Behaviour of low calcium fly ash based geopolymer concrete structural elements with GGBS & steel fiber" International Journal of Scientific Research Engineering & Technology ISSN 2278 – 0882

[14] Mark Reed and Warna Karunasena (2014) "Fibre-reinforced geopolymer concrete with ambient curing for in-situ applications."

[15] Mark Reed and Weena Lokuge(2014) "Fibre-reinforced geopolymer concrete with ambient curing for in-situ applications." Journal of Materials Science paper Final citation ISSN 0022-2461

[16] T.S. Ng, T.N.S. Htut & S. J. Foster (2010) "Mode I and II fracture behavior of steel fiber reinforced high strength geopolymer concrete" ISBN 978-89-5708-182-2.