JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

EFFECT OF LIME AND SILICA FUME ON MECHANICAL AND DURABLE PROPERTIES OF FLYASH AND GGBS BASED GEOPOLYMER CONCRETE

C.Abhishek [1], M.Deepak [2], Dr.K.V.S.Gopala Krishna Sastry [3],C.Chandana Priya[4]

[1]M.Tech student, Civil Engineering Department, G. Pulla Reddy Engineering College, Kurnool,

[2]Assistant Professor, Civil Engineering Department, G. Pulla Reddy Engineering College, Kurnool,

[3]Professor, Civil Engineering Department, G. Pulla Reddy Engineering College, Kurnool,

[4]Assistant Professor, Civil engineering Department, G. Pulla Reddy Engineering College,

ABSTRACT

The composite's viability and sustainability have been constrained by the requirement to cure fly ash-based geopolymer at high temperatures. Finding methods to cure fly ash GGBS-based geopolymers under ambient conditions is therefore urgently needed. The effects of lime and silica fume on the characteristics of geopolymer concrete cured under ambient conditions are experimentally investigated and the results are presented in this work. The fresh, strength, and microstructure of the geopolymer concrete were studied as a result of the partial replacement of fly ash as an aluminosilicate precursor with lime and silica fume . The results of this investigation demonstrated that raising the silica fume content increases the slump and set ting times of the geopolymer concrete while increasing the lime content decreases them. The best compressive strength was also produced when lime and silica fume, at 7.5% and 2% respectively, were used in place of fly ash. An examination of the microstructure revealed that the GPC's use of both lime and silica fume produced a densified microstructure.

Keywords: Geopolymer ,Fly ash, GGBS, Lime, Silica fume.

INTRODUCTION

Due to the lack of Portland cement (PC) as a binding agent in the concrete, geopolymer concrete (GPC) has recently attracted a lot of interest. High levels of human-induced carbon emissions and unfavorable use of natural resources have been linked to PC production. GPC uses low-calcium fly ash that has been activated with alkali as the binder, among other aluminosilicate precursors. However, the requirement to cure such geopolymers at high temperatures in order to speed up the dissolution of the monomers has led to a correspondingly high energy consumption and emission of greenhouse gases. Additionally, the restricted application of such geopolymers was due to the need for high curing, which is impracticable for the majority of applications. There is a need to develop methods for treating GPC under ambient settings in order to enhance and optimize its sustainability while advancing its practical uses.

FA-based geopolymers have longer setting periods when cured in ambient conditions, which reduces their early strength. By including additional precursors, such as blast furnace slag, FA-based geopolymers' early strength and setting can be enhanced (BFS).To get decent characteristics, though, this always required using BFS at a higher level than FA. The setting time and early strength of fly ash-based geopolymers can be improved by including calcium hydroxide (also known as lime), a weak alkali with a high calcium concentration. According to Provis, Nath, and Sarker, adding more calcium to geopolymers made them stronger and set up quicker since more products formed as a result. Additionally, by adding waste materials like silica fume, more silicate may be added to the geopolymer system. The strength of the resultant composites has been observed to rise with an increase in the silicate to aluminate ratio in geopolymers. But there is also a comparable rise in setting time when additional silicate is added to geopolymer systems. In addition to enhancing the performance of the composite, the ability to cure fly ash-based geopolymers opens up the possibility of using this concrete in a variety of building applications.

Therefore, the primary goal of this study is to assess how the fresh and hardened characteristics of GPC that have been cured at room temperature are affected by the use of lime (LM) and silica fume (SF) as a reduced replacement of the FA. In this investigation, lime and silica fume were both employed to substitute FA up to 10% and 3%, respectively. The characteristics of the combination of geopolymer concrete that included LM and SF as replacements for FA were explored after the precursors employed (i.e. FA and SF) were described. The geopolymer concrete that included the ideal dose of LM and SF also underwent microstructural studies.

2. EXPERIMENTAL STUDY:

A. Materials

As binders, fly ash, GGBS, lime, and silica fume with specific gravities of 2.6, 2.9, 2.3, and 2.64 are utilized. Alkaline activator solutions include sodium hydroxide and sodium silicate. Table1 displays the materials' chemical make-up.

Table1:

S.NO	Chemical composition	Fly ash	GGBS	Lime	Silica fume
1.	SiO2	60.342%	40.55%	-	99.886%
2.	Al2O2	30.834%	12.83%	-	0.043%
3.	Fe2O3	3.346%	1.10%	-	0.040%
4.	TiO2	1.878%	0.75%	-	0.001%
5.	CaO	0.801%	35.28%	68%	0.001%
6.	MgO	0.0548%	5.87%	0.6%	0.000%
7.	Na2O	0.082%	0.79%	-	0.003%
8.	k2O	1.268%	0.68%	-	0.001%

Fine aggregate & Coarse aggregate

For the experimental program, fine aggregate had been procured locally and had been graded in accordance with IS: 383-2016. Before being washed to remove dust, fine aggregate was first sieved using a 4.75mm sieve to eliminate any particles larger than that size. Locally accessible granite-type coarse aggregates with nominal sizes of 20mm and 12mm were employed in this investigation. The following table2 lists the results of laboratory tests on coarse aggregate that were conducted in accordance with IS: 2386 part(3)-1963 to determine the different physical qualities.

Table 2:

S.NO	Property	Fine Aggregate Test result	Coarse Aggregate(20 mm) Test result	Coarse Aggregate(12mm) Test result
1.	Specific gravity	2.77	2.8	2.79
2.	Fineness modulus	2.66	2.88	-

3.	Bulk density (loose)	1403.77kg/m3	1279.24kg/m3	-
4.	Bulk density (with compaction)	1483.96kg/m3	1402.83kg/m3	-
5.	Water absorption	0.8%	0.5%	0.5%

Superplasticizer

Conplast SP430 DIS is the superplasticizer in use.

Conplast SP430 DIS is a brown liquid that rapidly disperses in water and is based on Sulphonated Naphthalene polymers. Depending on doses, Conplast SP430 DIS conforms with IS:9103, BS:5075, and ASTM-C-494 type "A" and type "G." It has been carefully developed to generate high-quality concrete with decreased permeability or to offer large water reductions without losing workability.

Specific gravity is 1.2

Chloride content is NIL (as per BS 5075 part 1)

Air entrainment as per IS 9103

3.Mix proportions

The binder composition for the 10 mixes under investigation is summarized in Table 3. The percentage of FA that is substituted with LM and SF, respectively, is shown by Mixture ID in Table 3. For instance, 5LMSF3 denotes a combination in which 5% and 3% of the FA were replaced by LM and SF, respectively, while maintaining the GGBS proportion unchanged at 20%. Based on density, the ratio of the binder to the fine and coarse aggregates is set at 1:1:3 for all mixes. In the range of 5 – 10% and 1 – 3%, respectively, the LM and SF were employed to partially replace the FA.

Table3: Binder composition for mixture(%).

Mixture ID	Fly ash(FA)	GGBS	Lime(LM)	Silica fume(SF)
0LMSF0	80	20	0	0
5LMSF1	74	20	5	1
5LMSF2	73	20	5	2
5LMSF3	72	20	5	3
7.5LMSF1	71.5	20	7.5	1
7.5LMSF2	70.5	20	7.5	2
7.5LMSF3	69.5	20	7.5	3
10LMSF1	69	20	10	1
10LMSF2	68	20	10	2
10LMSF3	67	20	10	3

4. Results and discussion

4.1 Mechanical Properties

4.1.1 Compressive Strength

Fig. 1 displays the compressive strength of GPC that has been cured in ambient conditions. The figure shows that the compressive strength of all GPC increased with age, regardless of the binder amount. It can be shown from Fig. 1 that the compressive strength after 28 days increased up to 2% content of SF for combinations integrating 5% and 7.5% LM as a partial replacement of FA before it starts to drop. However, the compressive strength for GPC rose up to a content of 3% SF when 10% LM was used as a replacement for FA. Additionally, it can be observed that for all SF contents, GPCs created with 5 and 7.5% LM have compressive strengths that are higher than those made with 10% LM. The system's excess calcium may be the cause of the system's decreased strength at greater LM contents. Nevertheless, 7.5% and 2% of LM and SF, respectively, are thought to be the ideal concentrations. The GPC's 28-day compressive strength after replacing FA with LM and SF as 7.5% and 2%, respectively, is 68.9Mpa.

Table 4.1.1: Compressive strength

MIX	TYPE OF CONCRETE	28 DAYS OF COMPRESSIVE STRENGTH (Mpa)
Mix 0	0LMSF0	42.4
Mix 1	5LMSF1	51
Mix 2	5LMSF2	55
Mix 3	5LMSF3	52
Mix 4	7.5LMSF1	61
Mix 5	7.5LMSF2	68.9
Mix 6	7.5LMSF3	62
Mix 7	10LMSF1	54
Mix 8	10LMSF2	56
Mix 9	10LMSF3	51

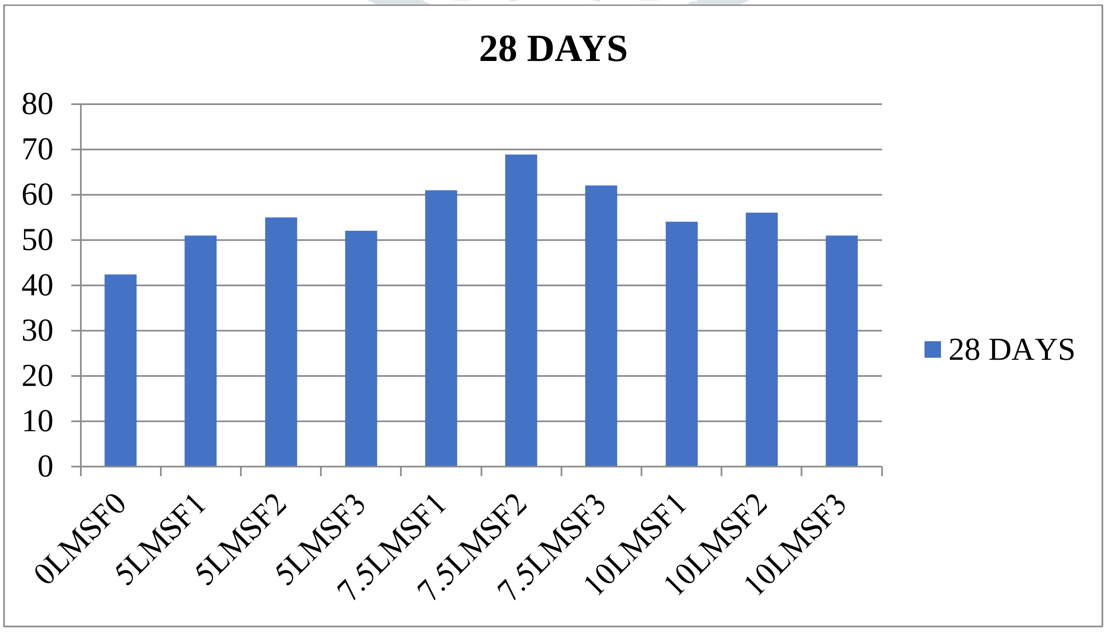

Fig4.1. Compressive strength of GPC

4.1.2. Flexural strength

Test of flexural strength. By casting beams with conventional dimensions of 100 mm by 100 mm by 500 mm, a flexural testing equipment is used to assess the flexural strength of concrete. According to IS 516, the testing is completed after 28 days at the usual room temperature.

The findings of the samples' flexural strength are given in the graphs below. The standard mix's 28-day flexural strength is 4.8 Mpa. The 28-day flexural strength of the 7.5% lime and 2% silica fume combination was raised, coming in at 6.9 Mpa, which is 43% greater than the usual mix.

Table 4.1.2: Flexural strength

MIX	TYPE OF CONCRETE	28 DAYS OF FLEXURAL STRENGTH(MPa)
Mix 0	0LMSF0	4.8
Mix 1	5LMSF1	5.7
Mix 2	5LMSF2	6.05
Mix 3	5LMSF3	5.3
Mix 4	7.5LMSF1	6.5
Mix 5	7.5LMSF2	6.9
Mix 6	7.5LMSF3	6.35
Mix 7	10LMSF1	5.8
Mix 8	10LMSF2	5.7
Mix 9	10LMSF3	5.6

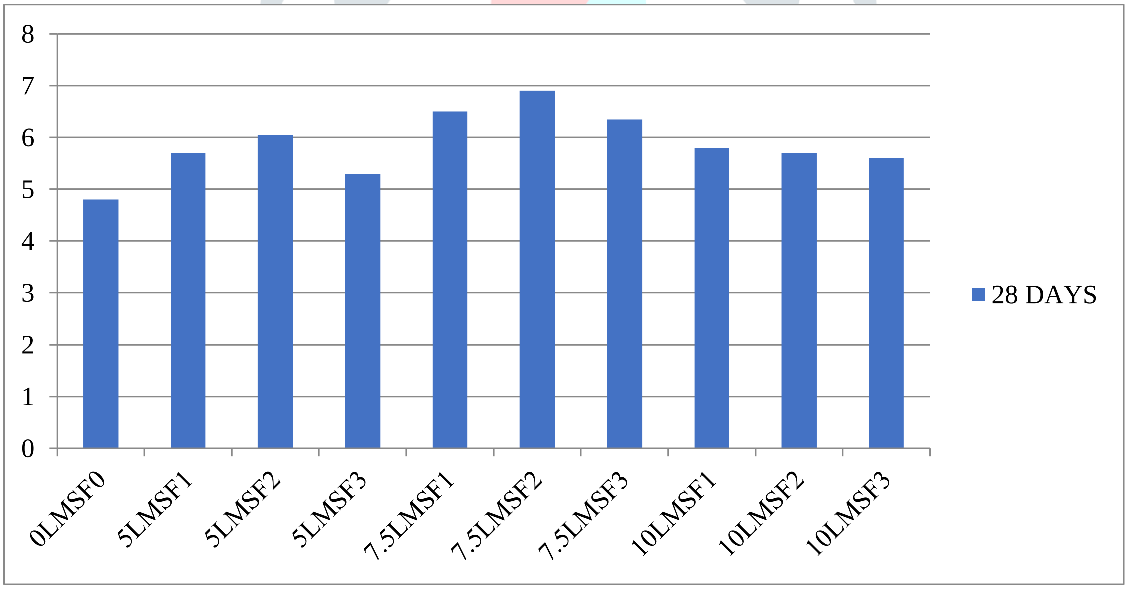

Fig 4.1.2 Flexural strength

4.1.3. Split tensile strength

Tensile strength test for splitting. On the compressive testing equipment, an indirect test is conducted to ascertain the tensile strength of a cylindrical specimen. According to IS 5816, a cylindrical specimen with dimensions of 100 mm in diameter and 200 mm in length is examined for 28 days at standard room temperature.

The graphs below show the results of the samples' flexural strength. The 28-day flexural strength of the normal mix is 4.26 Mpa. The 7.5% lime and 2% silica fume mixture's 28-day flexural strength was improved, measuring 5.5 Mpa, or 29% more than the standard mix.

Table 4.1.3: Split tensile strength

MIX	TYPE OF CONCRETE	28 DAYS OF SPLIT TENSILE STRENGTH(Mpa)
Mix 0	0LMSF0	4.26
Mix 1	5LMSF1	4.45
Mix 2	5LMSF2	4.61
Mix 3	5LMSF3	4.35
Mix 4	7.5LMSF1	5.1
Mix 5	7.5LMSF2	5.5
Mix 6	7.5LMSF3	5.15
Mix 7	10LMSF1	4.5
Mix 8	10LMSF2	4.83
Mix 9	10LMSF3	4.46

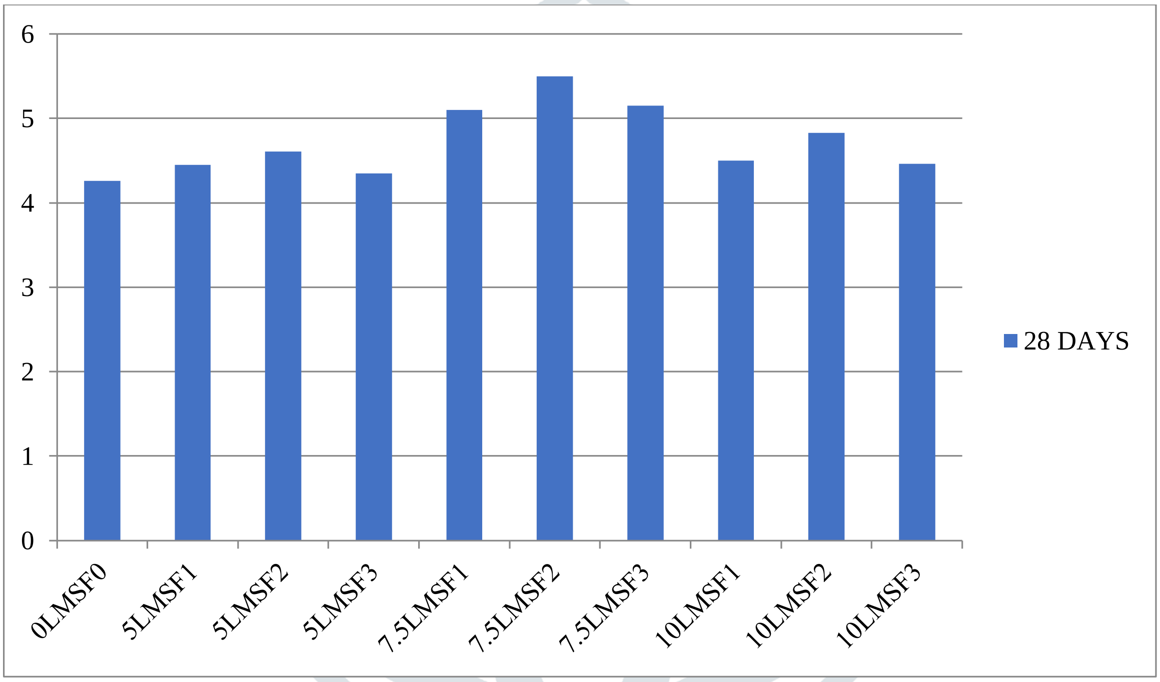

Fig 4.1.3 Split tensile strength

4.2. DURABILITY PROPERTIES

4.2.1. SULPHATE ATTACK

To evaluate the durability of specimens made from various replacement percentages, sulphate attack tests are conducted. The starting weights (dry weights) of the concrete cubes made from the control or standard mix, as well as the remaining mixes, are recorded after casting and curing for 28 days. The cubes are also immersed right away in the magnesium sulphate solution for 28 days. The samples are removed from the solution after 28 days, and their decreased weights are calculated. Similar to this, each specimen's compressive strength is determined. The control mix and hybrid mixes are both given a 28-day curing period, and it is discovered that just a very small coating of white precipitate has formed on the exterior of the concrete in both cases**.** Concrete that has been water cured for 28 days and concrete that has been treated in a magnesium sulphate solution for 28 days are both tested for compressive strength**.**

Table 4.2.1: Sulphate attack

S.NO	Mixes	Compressive strength of 28 days of normal curing (Mpa)	Compressive strength after 28 days of magnesium sulphate curing (Mpa)	Reduction in strength	Reduction in weight
1.	0LMSF0	42.4	37.96	10%	8.01%
2.	7.5LMSF2	68.9	65.45	5%	2.83%

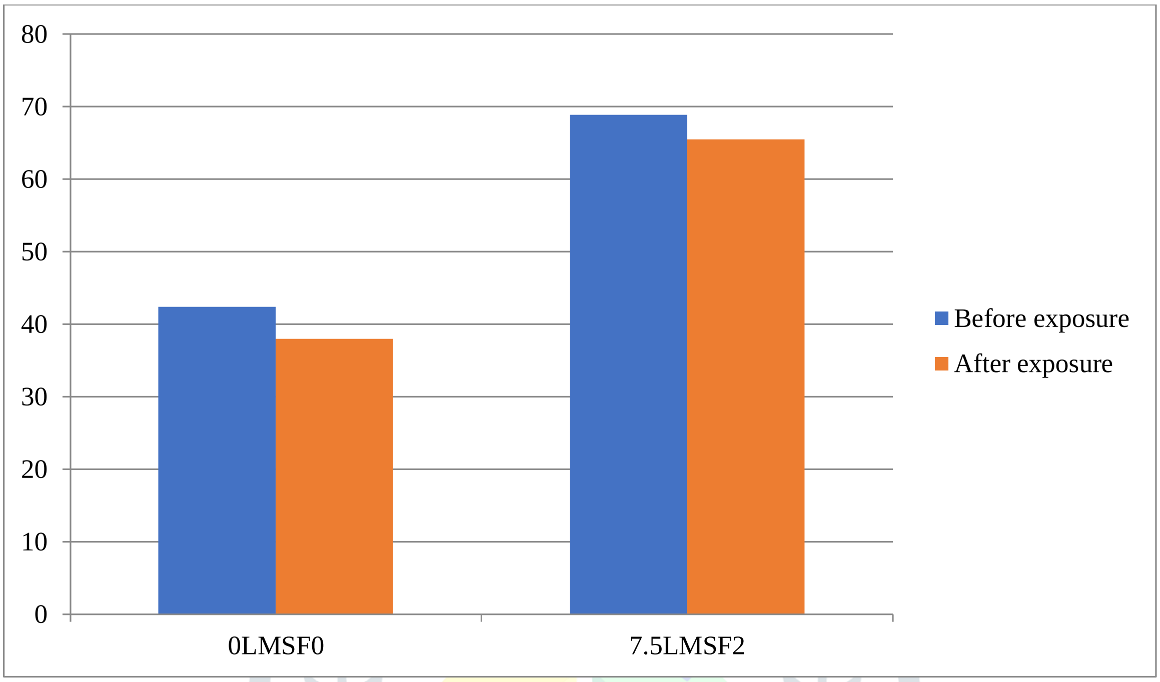

Fig 4.2.1 sulphate attack

Compressive strength for mix 0 is found to decrease by 8%, whilst compressive strength for mix 5 is found to decrease by 2.83%. Figure 4.2.1 displays the data that were observed.

Conclusion

In this study, the impacts of lime and silica fume on the properties of a geopolymer based on fly ash were evaluated. The results of the investigation showed that although these attributes can be improved with the use of SF, the workability and setting time of GPC may be shortened by switching LM for FA. Additionally, the compressive strength results demonstrate that when LM and SF are utilized as partial replacements for FA, replacing them to a degree of 7.5 and 2%, respectively, the strength is increased. The 28-day flexural strength of the 7.5% lime and 2% silica fume combination was 43% higher than that of the conventional mix. Furthermore, the 28-day split tensile strength of the 7.5% lime and 2% silica fume mixture was 29% greater than that of the conventional mix.

References

[1] L. K. Turner , F. G. Collins , Carbon dioxide equivalent (CO2 - e) emissions: a comparison between geopolymer and OPC cement concrete , Construct. Build. Mater. 43 (2013) 125 –130 , https:// doi. org/ 10. 1016/ j. conbuildmat. 2013. 01. 023 .

[2] J. Mishra , S. Kumar Das , R. S. Krishna , B. Nanda , S. Kumar Patro , S. Mohammed Mustakim , Synthesis and characterization of a new class of geopolymer binder utilizing ferrochrome ash (FCA) for sustainable industrial waste management , Mater. Today Proc. (2020) In press , https:// doi. org/ 10. 1016/ j. matpr. 2020. 02. 832 .

[3] S. K. Das , J. Mishra , S. K. Singh , S. M. Mustakim , A. Patel , S. K. Das , U. Behera , Characterization and utilization of rice husk ash (RHA) in fly ash – blast furnace slag based geopolymer concrete for sustainable future , Mater. Today Proc. (2020) In press , https:// doi. org/ 10. 1016/ j. matpr. 2020. 02. 870 .

[4] S. K. Das , J. Mishra , S. M. Mustakim , An overview of current research trends in geopolymer concrete , Int. Res. J. Eng. Technol. 5 (11) (2018) 376 –381 .

[5] P. O. Awoyera , A. Adesina , A. Sivakrishna , R. Gobinath , K. R. Kumar , A. Srinivas , Alkali activated binders: Challenges and opportunities , Mater. Today Proc 27 (2019) 40 –43 , https:// doi. org/ 10. 1016/ j. matpr. 2019. 08. 199 .

[6] T. Bakharev , J. G. Sanjayan , Y. B. Cheng , Effect of elevated temperature curing on properties of alkali - activated slag concrete , Cement Concr. Res. 29 (1999) 1619 – 1625 , https:// doi. org/ 10. 1016/ S0008 - 8846 (99) 00143 - X .

[7] P. Nath , P. K. Sarker , Use of OPC to improve setting and early strength properties of low calcium fly ash geopolymer concrete cured at room temperature , Cement Concr. Compos. 55 (2015) 205 –214 , https:// doi. org/ 10. 1016/ j. cemconcomp. 2014. 08. 008 .

[8] Y. C. Wang , Y. J. Zhang , D. L. Xu , L. C. Liu , Influence of different curing temperatures on mechanical properties of alkali activated silica fume and fly ash based geopolymer , Mater. Res. Innov. 17 (2013) , https:// doi. org/ 10. 1179/ 1432891713Z. 000000000191 .

[9] J. L. Provis , Alkali - activated materials , Cement Concr. Res. 114 (2018) 40 –48 , https:// doi. org/ 10. 1016/ j. cemconres. 2017. 02. 009 .

[10] F. N. Okoye , S. Prakash , N. B. Singh , Durability of fly ash based geopolymer concrete in the presence of silica fume , J. Clean. Prod. 149 (2017) 1062 –1067 , https:// doi. org/ 10. 1016/ j. jclepro. 2017. 02. 176 .

[11] F. A. Memon , M. F. Nuruddin , N. Shafiq , Effect of silica fume on the fresh and hardened properties of fly ash - based self - compacting geopolymer concrete , Int. J. Miner. Metall. Mater. 20 (2013) 205 –213 , https:// doi. org/ 10. 1007/ s12613 - 013 - 0714 - 7 .

[12] D. Dutta , S. Thokchom , P. Ghosh , S. Ghosh , Effect of silica fume additions on porosity of fly ash geopolymers , J. Eng. Appl. Sci. 5 (10) (2010) 74 –79 .

[13] R. Bajpai , K. Choudhary , A. Srivastava , K. S. Sangwan , M. Singh , Environmental impact assessment of fly ash and silica fume based geopolymer concrete , J. Clean. Prod. 254 (2020) 120147 , https:// doi. org/ 10. 1016/ j. jclepro. 2020. 120147 .