PALM FIBER EMBEDDED NANO SILICA BASED GEOPOLYMER FERRO CEMENT SLABS

D.DEVA RAJA SUBHA[a]*, J.S.PACKIA SANTHINI[a], N.SUBASH[b], P.RAJA LEKSHMI[c]

[a] *Assistant Professor, Ponjesly College of Engineering, Tamil Nadu, India*

[b] *Assistant Professor, University College of Engineering, Tamil Nadu, India*

[c] *Assistant Professor, Gopalan College of Engineering and Management, Karnataka*

ABSTRACT

The use of non-corrodible reinforcements in ferrocement slabs may prevent its failure due to corrosion of weld mesh embedded. This research aims into using palm fiber as a reinforcement in ferrocement slabs. Palm fiber with a thickness of 2 mm and a breadth of 6 mm is utilised as reinforcement. The palm fibers organized similarly to the weld mess of inner space 2.50cm. Cement mortar and geopolymer mortar in a 1:2 ratio are used to cast ferrocement slabs measuring 1000 mm x 300 mm x 25 mm with palm fiber as reinforcement. Flyash, granulated blast furnace slag, and nano silica were used to make a geopolymer mortar. The observed load to deflection behavior of slabs under two point loading is discussed.

Keywords : *ferrocement slabs, palm fiber, geopolymer mortar, nano silica.*

1 INTRODUCTION

The overall usage of cement as OPC and PPC plays an important role in global warming and environmental pollution. The world's atmosphere is mostly enveloped with 7% of hazardous gases due to cement production .The overall global heat is also raised year by year. This can be only minimized by using alternative material on behalf of cement[1]. In this present study, the cement mortar is totally avoided in the ferro cement slabs. The cement mortar is replaced by geopolymer mortar. The technology introduced by Davidovids is used to have the geopolymer mortar. Even though fly ash is used as basic source material of geopolymeric mortar , it shows some drawbacks when compared with cement mortar . Some of the properties, which vary hugely when compared to cement mortar, are cost, setting time, curing temperature, method and strength. However, it resembles cement mortar to a certain degree when GGBS is used as the general source material in

* For Correspondence *subhajith107@gmail.com*

making geopolymer mortar[2]. The structure of geopolymer mortar shows less property when compared to the cement mortar. Nano silica when added to mortar to increase its strength and durability [3]. This research gives space to utilise nano silica in ferrocement mortar. On the other hand, corrosion of reinforcement in ferrocement members is very quick. Failures avoid due to this reason is frequently happening. Palm fiber in concrete increases the tensile strength of concrete. It is a naturally available fiber with high durability. This fiber is used in this research as reinforcement instead of weld mesh. Comparative studied are carried out for the ferrocement slabs with weld mesh and palm fiber as reinforcements.

2 MATERIALS USED

GGBS, obtained from Dindukal steel limited, Dindukal, India with specific gravity 3.0. Flyash, obtained from Thoothukudi power plant with specific gravity 2.3. River Sand confirms to zone II [IS 383-1987], 2.75 as specific gravity and with 3.5 as the fineness modulus are used. It was confirmed as per IS383-1987 and was tested according to IS 2386-1963. Nano silica was obtained from Aastra chemicals, Chennai, India. The alkaline solution was formed by mixing sodium hydroxide and sodium silicate.

The sodium hydroxide, purchased from chemical agencies in the form of flakes and dissolved in water to have 10 M solution. Similarly the sodium silicate also obtained with a mass consists of sio_2 = 29%; Na_2O = 15 %; H_2O = 56% were used. The ratio of sodium silicate and sodium hydroxide was kept to be 2.3. To enhance good workability, high range water reducing naphthalene based super plasticizer from BASF Ltd was used. Glenium was used as the super plasticizer. Welded wire mesh of 1” x 1” size was obtained from locally available steel store. The thickness of wire mesh was found to be 5mm. Palm fiber of size 2mm thick and 4 mm width is used in this work. This fibers are bought from the village people of south India.

3. MIX PROPORTION

The mortar was prepared in 1:2 ratio. The binder was designed in such a way which consists of flyash, sodium silicate, and sodium hydroxide. The total volume of binder occupied by 65% of flyash and 35% of solids in the alkaline solution. The percentage of H_2O in the alkaline solution should not be considered, if did so, leads to volumetric shrinkage. The mix proportions are given in table 1.

Table 1 Mix proportion of Geopolymer mortar

Mix	% of GGBS	Flyash (kg/m^3)	GGBS (kg/m^3)	Fine aggregate (kg/m^3)	S.H (kg/m^3)	S.S (kg/m^3)	Super plasticizer %	Water (l/m^3)
1	0	455	-	1400	75	170	2	4
2	20	364	91	1400	75	170	2	4
3	40	273	182	1400	75	170	2	4
4	60	182	273	1400	75	170	2	4
5	80	91	364	1400	75	170	2	4
6	100	-	455	1400	75	170	2	4

The optimized mix from the above table is added with nanosilica as 0.5, 1, 1.5 & 2% by weight of powder (Flyash & GGBS) to get high strength geopolymer mortar.

4 PREPARATION OF FERROCEMENT SLAB SPECIMENS

The dry materials are mixed together in a pan with that the alkaline solution, superplast and water are added. The materials are thoroughly mixed and specimen of about 50mm x 50mm x 50mm are cast. The cast specimens are kept in room temperature for curing. The water curing is not allowed. The specimens kept in open air curing was taken for testing on the specified day. The ferrocement slabs are cast with dimensions 700mm x 300mm with constant depth of 25mm. Initially the wire mesh was cut down for the dimension mentioned. With a cover depth of 3mm, the weld mesh should be placed over the mortar, and again the mortar should be poured over the mesh and finishing should be done. The finished slabs should be removed from the mould after 5 hrs from the time of casting. The finished specimens should be numbered on the next day and kept in open air until the day of testing.

5 TESTS CONDUCTED

Compressive strength test

The cube specimens cast for each proportion of size 50mm are tested under compression load at 3, 7 and 28 days. The specimens are tested in compression testing machine of 2000 KN capacity. As per IS 516-1959, the compression test was conducted.

Flexural strength test on ferrocement slabs

The cast ferrocement slabs are tested on 28 day. Testing of slabs are done on universal testing machine of 400 KN capacity. The support for the slabs are provided at 25mm from each end and thus 650 mm can be kept as effective span. Two point loading is given on the slabs by using iron rods. The deflection was noted down by keeping LVDT at mid span of slabs.

6 RESULTS AND DISCUSSIONS

Compressive strength

The compression strength of the mortar specimens with different percentage of GGBS are tested on 3, 7, and 28 days and the results are given in table 2 and fig 1.

Table 2 Compressive strength of geopolymer mortar

Mix	% of GGBS	**Compressive strength** (N/mm^2)		
		3 days	**7 days**	**28 days**
1	0	3.65	6.34	8.54
2	20	5.32	8.34	10.45
3	40	6.89	9.15	12.76
4	60	7.83	9.89	13.38
5	80	8.62	10.52	14.53
6	100	9.34	11.35	15.75

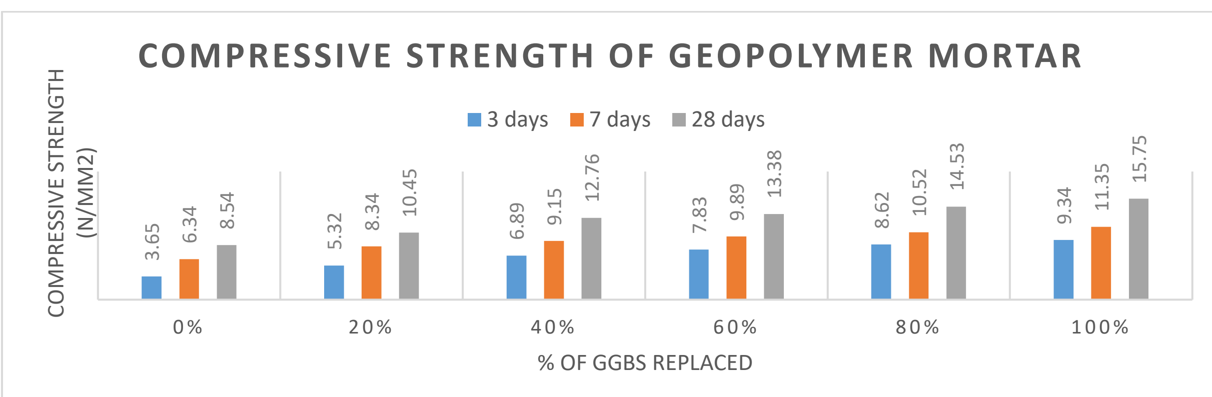

Fig 1 Compressive strength values of geopolymer mortar with different % of GGBS

The Specimen with 100% of fly ash attains its final setting time only after 4 days. But with the addition of GGBS the setting time was found to get decrease similar to cement mortar. For each 20% replacement of flyash by GGBS the strength got increased. The maximum strength was achieved at 100% replacement of flyash with GGBS. Nearly 85%of strength was increased from the control specimen. Even though 100% of GGBS gained optimum, some small cracks are found over the surface of the cube specimens. It is not advisable for slabs. So the mix with 80% GGBS and 20% of flyash was concluded as the optimized mix and the strength was 70% increased from the control specimen. Nano silica was added with the optimized specimen of about 0.5, 1, 1.5 and 2% by weight of powder content. The weight of powder can be derived from the sum of weight of GGBS and flyash. The strength of the specimens with nano silica are tested and shown in table 3.

Table 3 Compression strength of geopolymer mortar with Nano Silica

Mix No	% of GGBS	% of flyash	% of Nano silica	Compressive strength (N/mm^2)		
				3 days	7 days	28 days
1	80	20	0	5.63	11.35	29.24
2	80	20	0.5	6.85	13.87	31.45
3	80	20	1	7.62	15.34	33.45
4	80	20	1.5	8.23	16.45	35.67
5	80	20	2	9.17	18.34	30.67

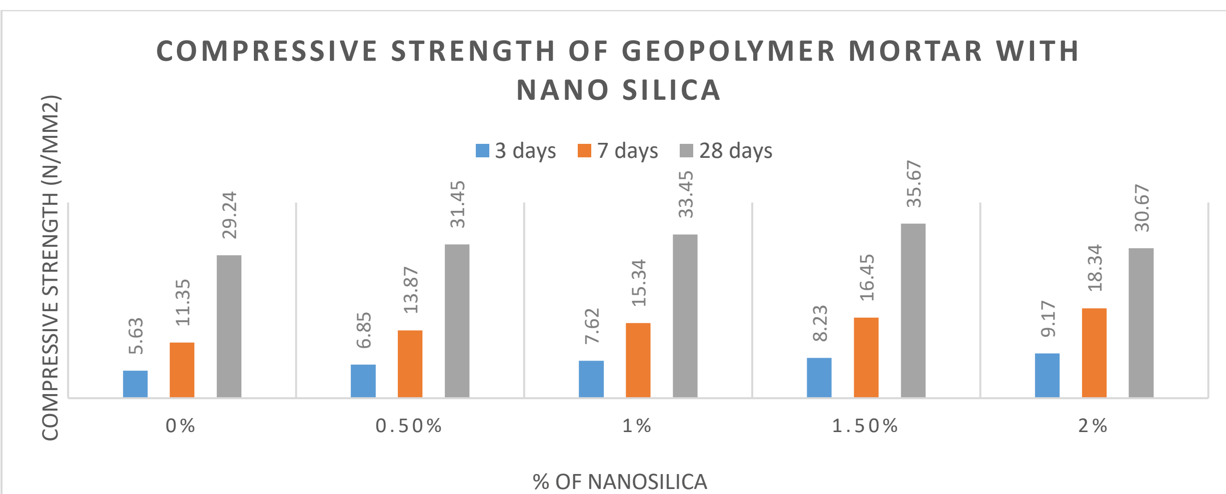

Fig 2 Compressive strength value of geopolymer mortar with different % of Nano silica.

The addition of Nano Silica increases the workability with addition of extra water (approx. 1lt/m^3/0.5% of Nano Silica). The pores of mortar specimen were found to get arrested with the addition of Nano silica. With every addition of 0.5% Nano silica, the strength got increased. But after 1.5% of addition of Nano Silica, the strength was found to get decreased. The strength was increased by 22% from the optimized mix with 1.5% of Nanosilica.

6.2 Flexural strength of ferocement slabs

The flexural strength of the cast slabs tested in Universal Testing Machine are noted down and shown in table 4.

Table 4. Flexural strength of Ferrocement slabs under various criteria's

Slab ID	**% of GGBS**	**% of Fly ash**	**% of Nano Silica**	Type of Reinforcement	**Load (kN)**	**Deflection (mm)**
S_1	0	100	0	Palm	1.0	5
S_2	0	100	0	Steel	3.0	9
S_3	80	20	0	Palm	2.0	6
S_4	80	20	0	Steel	4.5	10
S_5	80	20	1.5	Palm	3.5	5
S_6	80	20	1.5	Steel	6.0	11

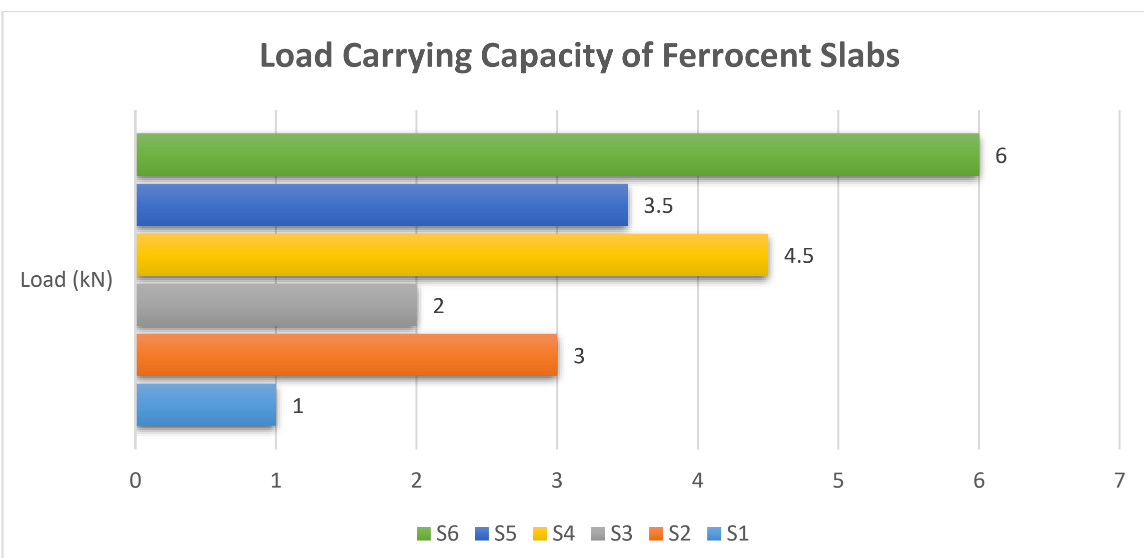

Fig 3 Flexural strength of the ferrocement slabs with varying mortar and reinforcement

Results shown in table 4 clearly indicates the strength of ferrocement slabs with palm fiber and steel as reinforcement. Based on the addition of three types of mortar proportions, the strength got varied. The result variation between the steel and palm based ferrocement slabs are found to be within 50%.

7 CONCLUSION

Geopolymer mortar achieved considerable strength with the addition of GGBS with flyash based geopolymer binder. The strength of flyash based geopolymer mortar with the addition of GGBS got increased upto 80% of its compressive strength. Nano silica of about 1.5% with optimized geopolymer mortar increased its strength upto 21% of its compressive strength. The strength behavior of geopolymer ferrocement slabs with palm fiber as reinforcement got a reduction of strength about 50% when compared to the slabs with steel as reinforcement. The deflection rate between palm fiber and steel based geopolymer ferrocement slab is nearly 0.5.

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