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Flexural Behaviour of Ferro cement Slab by Using GGBS and Nano Silica

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Abstract- The aim of this experimental investigation is to find the flexural behavior of ferro cement slab. Fly ash and GGBS are completely replaced instead of cement. The cement is the most important material in the construction sector. But the cement production from the manufacturing units affects the environment, due to the emission of CO_2 and greenhouse effect. GGBS is an alternative construction material, produced by the chemical action of inorganic molecules. It is produced as a by-product from iron industries. GGBS shows a greener substitute for Ordinary Portland Cement. Fly ash, a by-product of coal obtained from the thermal power plant is abundantly available worldwide. Fly ash which is rich with silica and alumina activated with alkaline activators form alumino-silicate gel that acts as the binding material for the concrete. It is an excellent alternative construction material to normal concrete without any amount of ordinary Portland cement. The presence of Nano silica contributed to the improvement of compressive strength and split tensile strength.

Indexed Terms- GGBS, Nano-silica, fly ash, alumino-silicate gel, compressive strength, split-tensile strength.

I. INTRODUCTION

Cement is the major ingredient used in construction industry. In the current situation, strength is given equal importance in accordance with durability. The IS 456: 2000 recommends the minimum cement content to satisfy the strength and durability. Hence, the usage of cement is getting increased. But the cement production consumes large amount of energy and emits CO_2. The best solution to reduce the over consumption of cement is by utilizing the pozzolona materials for the preparation of concrete. Previous studies shows that the use of fly ash, nano silica, GGBS as replacement of cement reduces the cement consumption and also increases the strength and durability of concrete. To improve the performance of concrete, nano materials are now being introduced as supplementary materials. Due to the smaller particle size and high surface areas compared to the other pozzolonic materials, the use of nano-silica possibly enhances the performance of concrete more effectively. As the nano silica particles are very fine and they tend to agglomerate due to high surface interaction, uniform dispersion of nano silica is an important issue to get its beneficial effects. GGBS is a by-product of iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace and the resulting molten slag floats above the molten iron at a temperature of about 1500ºC-1600ºC. The molten slag has a composition of about 30% to 40% SiO2 and about 40% CaO, which is close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which consists of mainly silicious and aluminous residue is then water-quenched rapidly, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size, which is known as Ground Granulated Blast Furnace Slag (GGBS). The production of GGBS requires little additional energy as compared with the energy needed for the production of Portland cement. The replacement of Portland cement with GGBS will lead to significant reduction of carbon-di-oxide emission. It is therefore an environmentally friendly construction material. It enhances lower heat of hydration which reduces the risk of thermal cracking. It has higher durability, workability, reduces permeability to external agencies, which helps in making, placing and compaction easier. Geopolymer is used instead of water. The activator solution used in thin work is NaOH and sodium water glass.

II. LITERATURE REVIEW

S.Arivalagan[1] investigated the strength and strength efficiency factors of hardened concrete, by partially replacing cement with 20%, 30% and 40% GGBS at different ages. The specimens when tested at 7 and 28 days, showed increase in compressive strength for 20% replacement of cement. Split tensile strength and flexural strength of concrete also increased at 20% cement replacement. The increasing strength is due to filler effect of GGBS. It was also found that the degree of workability of concrete was normal and it increased with the addition of GGBS.

M. Mohd et. al. [2] focused on the topic "A review on fly-ash based geo polymer concrete without Portland cement". The study includes various parameters such as curing process, compressive strength, workablility, resistance against aggressive environment and behavior of geopolymer at elevated temperature. The study concluded that normal concrete in many aspects such as workability, exposure to aggressive environment, exposure to elevated temperature and compressive strength.

Sabeer Alavi. C et. al. [3] studied the effects of partial replacement of cement with 0-50% of GGBS and found that 30% GGBS replacement is good as beyond that the compressive strength start decreasing. He also concluded . It was also found that the workability increases with the increase in percentage of GGBS.

Atul Dubey et. al. [4] examined the effects of partial replacement of cement with 5 to 30% of BFS on compressive strength of concrete. The test was conducted at 7, 14 and 28 days on cubes made of standard size 150 mm x 150 mm x 150 mm. He concluded that as the percentage of BFS increases, the strength tends to decrease. On replacement of OPC with 15% blast furnace slag is being near about only 5%.That the split tensile strength and flexural strength conducted at 7 and 28 days increases with increase in GGBS content

Ahamad Askari et. al. [5] done an experimental investigation into mechanical properties of self compacting concrete incorporating fly ash and silica fume at different ages of curing. Self compacting mixtures had a cement replacement of 20%,30%and 40% with class F fly ash and 5%,10% and 15% with silica fume, the results show that normal strength self-compacting concrete could be successfully produced using fly ash and silica fume.

III. EXPERIMENTAL PROGRAMME

- Materials used

The materials used in this experiment are GGBS, fly ash, fine aggregate and water, cement (conventional testing).

- CEMENT

The various physical properties of the cement (OPC 43 grade) are tested as per code IS: 12330-1988. The test results are tabulated in table 3.1.

Table 1 properties of cement

Physical properties	Test results	BIS specification: 12330
Specific gravity	3.17	3.15
Standard consistency	30%	-
Initial setting time	28 min	30 min
Final setting time	97%	-

- Fine aggregate

The fine aggregate passing through 1.18mm sieves is used for the concreting. The properties of FA are tested according to IS: 383-1970 and the results are tabulated in table 3.2

Table 2 properties of fine aggregate

Fine aggregate	Values
Size	passing through 1.18mm sieve
Bulk density	1721 kg/m^3
Fineness modulus	2.87
Specific gravity	2.47

Table3 Reinforcements in ferro cement

Table 3.3 Typical mortar compostiton

Portland cement	Any type depending on application
Sand to cement ratio	1<s/c<2.5 by weight
Water to cement ratio	0.35<w/c<0.6 by weight
Recommendations	Fine sand all passing through U.S sieve No.16(1.5 mm) and having 5% by weight passing No.100 (0.25mm), with a continuous grading curve in between. Additives, air entraining agents, corrosion inhibitor.

IV. EXPERIMENTAL INVESTIGATION

- PRELIMINARY TEST

Under preliminary test, the properties of various ingredients used in ferro cement are studied.

- SPECIFIC GRAVITY TESTS

Table 4 specific gravity results

Specific gravity	Values
Cement	3.33
Fine aggregate	2.47
Fly ash	2.05
GGBS	2.43

- SIEVE ANALYSIS TEST

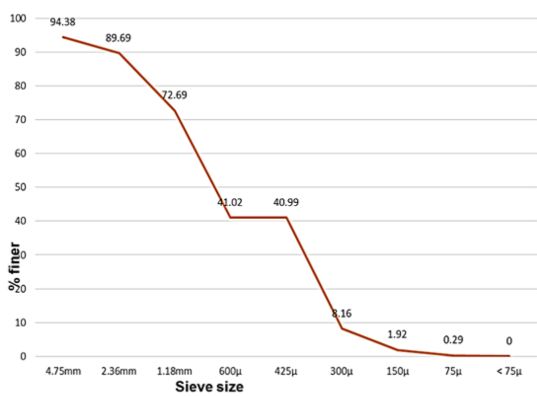

Fig 4.1 sieve analysis test

- MIX DESIGN
- MIX PROPORTION

Trial 1 (1.1)

Unit weight of mortar = 2300 kg/m^3

Mass of geo polymer paste =50 %

4.75 mm fine sand 50%=2300*50/100

=1150 kg/m3

Mass of fly ash and liquid=2300-1150

=1150 kg/m3

Take liquid to fly ash ratio=1

Liquid +fly ash =1150 kg/m^3

Mass of fly ash=1150/2

=575 kg/m^3

Mass of alkaline liquid=1150-575

=575 kg/m^3

Take sodium silicate to sodium hydroxide=2.5(Na2Sio3=2.5NaOH)

But sodium silicate+sodium hydroxide=575 kg/m^3

2.5 sodium hydroxide+sodium hydroxide= 575

Sodium hydroxide=575/3.5

Mass of sodium hydroxide=164.28 kg/m^3

Mass of sodium silicate=575-164=411 kg/m^3

- Material quantity for mix proportion

Table 5 mix proportion

Ingredients Kg/m^3	MC1	MC2	MC3	MC4
cement	790	632	526	450
proportion	1:1	1:1.5	1:2	1:2.5
Sand	790	946	1052	1126

- Material quantity for trial proportion

Table 6 mix proportion

Ingre dients Kg/m3	MC5	MC6	MC7	MC8	MC9
sand	1080	1080	1080	1080	1080
Fly ash	380	285	190	95	0
GGBS	0	95	190	285	380
NaOH	97	97	97	97	97

Sodium silicate	243	243	243	243	243

- Fly ash based geo polymer concrete

Table 7 Mix proportion

Ingredients Kg/m^3	FS1	FS2
sand	1080	1080
Fly ash	190	190
GGBS	380	380
NaOH	97	97
Sodium silicate	243	243
Nano silica	0%	0.25% of total
Size of mesh	700*250* 25	700*250* 25

V. EXPERIMENTAL RESULTS

Table 8 compressive strength of cement mortar

specimen	Load KN	Compressive strength (N/mm^2)
MC1	50	10.20
MC2	80	16.33
MC3	60	12.24
MC4	50	10.20

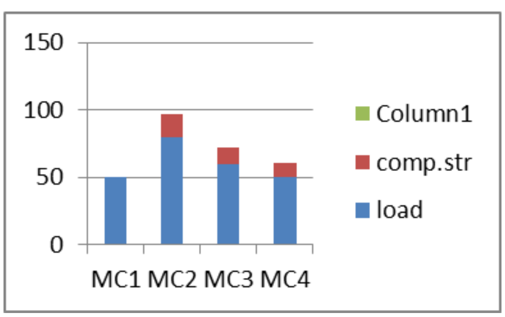

Fig 1 compressive strength of mortar

Table 9 Geo polymer mortar (water curing)

Specimen	Load (KN)	Compressive strength (N/mm2)
MC6	130	26.53
MC7	160	32.65
MC8	140	28.57
MC9	120	24.49

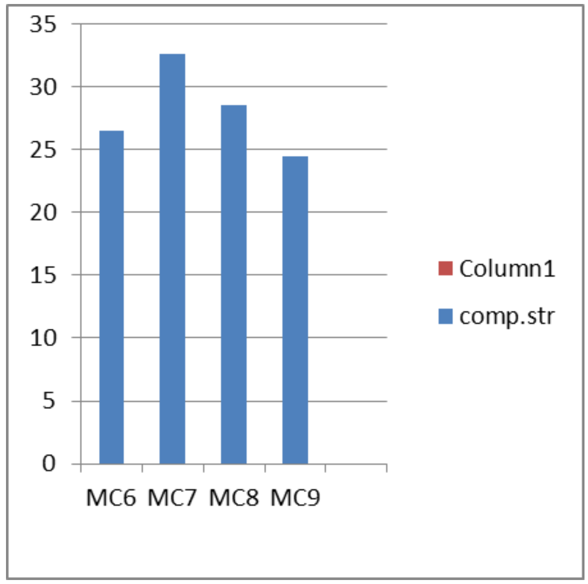

Fig 2 compressive strength of geo polymer mortar

- Deflection of slab

Table 10 Deflection of slab

specimen	Load failure	Avg load (KN)	Deflection at slab (mm)	Max deflction (mm)
Without nano silica	6.8 6.6	6.7	4 4	36.3
With nano silica	7.6 7.8	7.7	2 2	26.5

- Ball Bounce Test

Geo polymer ferro cement slab without nano silica=40 cm.

Geo polymer ferro cement slab with nano silica=50 cm.

- Impact value

Table 10 Impact value

specimen	Impact value (Joule)
Without nano silica	163
With nano silica	164

VI. CONCLUSION

The construction industry is in demand of eco-friendly and greener materials which are durable. As compared with existing concrete materials fly ash is advantageous but its uses as tested against strength and durability needs to be confirmed. The results of the experimental investigation indicate that the fly ash and nano-silica can be adopted as Ordinary Portland Cement replacement for concrete preparation. Using the test results, it can be concluded that with the increase in the percentage of nano-silica the various strength characteristics of concrete increased upto 3% with further increase in the nano-silica the strength characteristics are decreased for the given percentage of fly ash. The decrease in the strength characteristics of concrete with increase in the nano-silica content beyond 3% is due to the poor quality of binder formed in the presence of high content of nano-silica and fly ash. The various strength characteristics of concrete can be improved by the addition of 3% nano-silica and 20% fly ash content. It can be concluded that the cement content can be reduced without compromising the strength of concrete by the use of fly ash and nano silica combination at an appropriate proportion.

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