Performance of Ferrogeopolymer Slab Pannels

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Abstract

The world is in quest of innovative and ecological material for erection of buildings due to the amplified ultimatum and unjustified effects of the traditional building materials. The traditional building material such as Portland cement, river sand, blue metal, clay bricks etc. are in practice today. Between these materials, the manufacture of cement embraces a long tiresome process. It also ingests high energy proficiency and crops a lot of carbon dioxide to the atmosphere, which is a principal contributor to ecological inequity by increasing global warming. To overcome these hitch, a novel material so-called ferrogeopolymer is used to create slab panels. Ferrogeopolymer is a combination of geopolymer mortar and different forms of steel mesh as the reinforcement material. In this research ordinary Portland cement is completely replaced by fly ash as a binding material. Alkaline solution is used to enhance the binding property of fly ash. Different forms of steel meshes, such as square woven, square welded and chicken meshes are used. Ferrogeopolymer slab panels of size 1100mm x 350mm x 40mm are cast and tested. The crack behaviour, ductility and load carrying capacity of the slab panels are found, and the test outcomes are adequate.

Keywords: Activator solution, Crack behaviour, Ductility ratio, Ferrogeopolymer, Fly ash, Slab panels, Meshes.

1. Introduction

1.1. General

Need for a sustainable material in the field of construction filed is an emerging issue today. The development in the field of infrastructure of the country, there is a huge demand for construction materials. Especially the use of cement is drastically reaches the peak. Generally concrete is used as a construction material in the modern world. Cement is used as a binding material with sand and crushed aggregate to form concrete. As concrete is weak in tension, reinforcement is provided to hold the tension in reinforced concrete. Due to the need for cement is vastly increasing, the percentage of growth of greenhouse gases emission is also increasing day by day [6]. This made an elevation in the global warming rate [1]. So there is a need for new building material which should eco-friendly and should available in abundant quantity. Current research works are focussed their vision on finding sustainable materials for construction. There is also a need for technology to make thin and light weight concrete structures. This research is focussed on rectifying the emission of greenhouse gas and to create thin concrete elements. This is achieved by using ferrogeopolymer technique. In this work slab panels with ferrogeopolymer mortar is tried. In this technique the use of cement is completely eliminated and the sizes (thickness) of the structure is reduced [8]. This will make the structure eco-friendly and light weight structure.

1.2. Ferrogeopolymer

The term ferrogeopolymer is derived from combining two techniques into one. The geopolymer technique and the ferrocement technique are combined to form ferrogeopolymer. The advantage of the ferrocement technique is, that thin concrete elements are possible in the construction field. The advantage of geopolymer is, the use of cement is completely removed and utilisation of fly ash is elevated [3]. In ferrogeopolymer, the usage of coarse aggregate is not taken into account. It is made up of fly ash, Ground Granulated Blast Furnace Slag and sand with alkaline solution in the form of mortar. This geopolymer mortar is placed with different steel meshes to form ferrogeopolymer. The alkaline solution is added with the fly ash to initiate the binding property [4]. Another advantage of this research is the ferrogeopolymer concrete elements are cured under ambient curing. The curing of concrete under water for 28 days is not needed for ferrogeopolymer concrete elements. For the ferrogeopolymer concrete elements 24 hours curing is sufficiently enough.

2. Materials

2.1. Cement

Ordinary Portland Cement (OPC) 53 grade is used as a binder for conventional ferrocement slab panels. The cement sample used is confirming to the Indian standards requirements stipulated in IS: 4031 - 1988 and IS: 12269 – 1989. The specific gravity of cement sample is 3.12. The Figure 1(a) shows the cement used for casting ferrocement slab panels.

2.2. Fly Ash

The fly ash used in this study is Class – F type obtained from thermal power plant in Mettur. While burning the coal in thermal power plants, it produce fly ash as a waste material [3]. They are less in particle size compared to cement with small surface area. The specific gravity of fly ash determined through conducting test is 2.33. The figure 1(b) shows the fly ash used for making ferrogeopolymer slab panels.

2.3. Ground Granulated Blast Furnace Slag

Addition of GGBS in the ferrogeopolymer mortar will enhance the mechanical properties of ferrogeopolymer mortar and also it will ensure the ambient curing [7]. The by-product from the steel industries are similar to the constituent present ordinary Portland cement with different proportions [5]. It is known as Ground Granulated Blast furnace Slag. It consists of oxides of magnesium, aluminium, calcium oxide, silicon dioxide. The Specific of GGBS used in this research is 2.81. The figure 1(c) shows the GGBS used for making ferrogeopolymer slab panels.

2.4. River Sand

River sand is utilised as fine aggregate in the ferrogeopolymer mortar. The specific gravity of the river sand used in this research is found to be 2.70 and the fineness modulus of river sand is 3. The sieve analysis of river sand used confirms zone II as per IS: 383-1970 [2]. The figure 1(d) shows the river sand used for making ferrogeopolymer slab panels.

2.5. Activator Solution

It is the combination of sodium hydroxide and sodium silicate solution. It will enhance the binding property of ferrogeopolymer mortar by activating the binding property of fly ash. The properties of sodium silicate solution (Na_2SiO_3) and sodium hydroxide (NaOH) is shown in Figure 5. The concentration of the activator solution varies with the sodium hydroxide molarity. The ratio of sodium silicate solution and sodium hydroxide is 2.5 and activator solution to fly ash is 0.42. The figure 1(e) shows the materials used to form activator solution.

(a) Cement (b) Fly Ash (c) GGBS (d) Sand (e) NaOH (f) Na_2SiO_3

(f) Chicken Mesh (g) Welded Mesh (h) Woven Mesh

Fig.1. Materials used for casting slab panels

2.6. Steel Meshes

2.6.1. Chicken Meshes

The hexagonal mesh is commonly known as chicken mesh, and its shape gives the name as hexagonal. The wire mesh used in the ferrocement is usually 0.3mm in diameter and at joints 0.5mm and the mesh opening varies from 15mm to 25mm.The tensile strength of the wire mesh is 50 N/mm^2. Figure 1(f) shows the chicken mesh used in this research.

2.6.2. Welded Mesh

Generally 8 to 19 gauge wire spaced half an inch apart are normally used in the mesh. These wires are of low to medium tensile strength steel and are much stiffer than hexagonal wire mesh, but may develop weak spots at an intersection. The tensile strength of the material 532 N/mm^2. Figure 1(g) shows the chicken mesh used in this research.

2.6.3. Woven Mesh

In this type of mesh, the wire is simply woven into the desired grid size. Tests indicate that this is good ductility property. The tensile strength of woven mesh is 250 N/mm^2. The Figure 4.15 shows the wovened shape of mesh. Figure 1(h) shows the chicken mesh used in this research.

3. Experimental Investigations

3.1. *Compressive Strength of cement mortar and ferrogeopolymer mortar cubes*

The compressive strength of the specimens are determined by casting cubes specimens of size 100mm X 100mm X 100mm. Totally 12 number of cubes are cast, 6 for cement mortar and 6 for geopolymer mortar with mortar ratio of 1:2. The compressive strength of ferrocement mortar cubes after 28 days of curing and ferrogeopolymer mortar cubes after 7 days of ambient curing are shown in Table 1.

Table 1 Compressive Strength of ferrocement and geopolymer mortar cubes

Mix Ratio /Molarity	Curing Days	Compressive strength N/mm^2			Average N/mm^2
		1	2	3	
1:2	28	54.46	53.56	53.12	53.71
8M	07	54.52	55.92	55.75	55.40

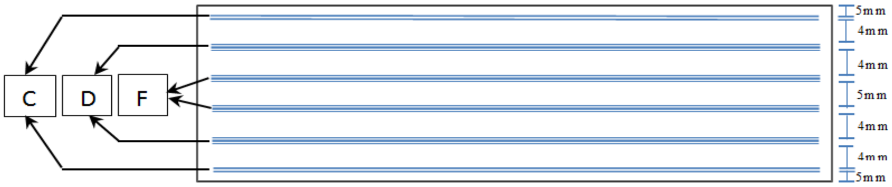
Table 2 shows the details of steel meshes in the slab panels. Each and every one of the meshes was combined with other meshes for convenient purpose.

Table 2 Specification of Slab Panels

Type of Specimen		Ferrocement Slab	Ferrogeopolymer Slab
Welded and woven with chicken mesh	Replaced with meshes	CW1	GW1

3.2. *Ferrocement and Ferrogeopolymer slab panel arrangements*

The Figure 3 represents the cross section of control ferrocement and ferrogeopolymer slab panels. The mortar cover of 5mm is given at both top and bottom. The mesh type B is placed with a cover mortar of 4mm and then D type mesh is placed with a cover of 4mm. Two F type mesh is placed with central mortar cover of 5mm



C-Welded + Woven, D -Welded +2 chicken meshes,
F -Woven + 2 chicken meshes.

Fig. 2. Cross Section of Slab panel (CW1 & GW1)

. The 4mm mortar cover on D type mesh on both top and bottom and C type is placed and finish cover of 5mm has given with smooth finishing. In this type of slab panel, steel skeletal is replaced by equal amount volume of mesh reinforcement.

3.3. *Casting and curing of slab panels*

The ferrocement slab and ferrogeopolymer slab panels are cast and cured for 28 days and 7 days respectively. The ferrocement slab panel is cured by water curing and ferrogeopolymer slab panel is cured by ambient curing.

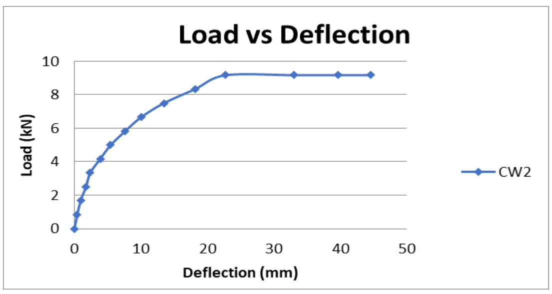
3.4. *Testing of slab panels*

3.4.1. Testing of Ferrocement slab panel (CW1)

The ferrocement slab containing woven mesh as a replacement for skeletal steel reinforcement takes 9.17 kN ultimate load with 44.6mm of ultimate deflection. The general setup for testing of slab panel is shown in Figure 3(a). The deflected shape of this slab is shown in Figures 3(b & c). The load-deflection curve obtained for CW1 is shown in Figures 3(d &e). The crack pattern of CW1 is shown in Figures 3(f & g). The ferrogeopolymer slab containing woven mesh with replacement for skeletal steel reinforcement takes 11.67 kN ultimate load with 48 mm of ultimate deflection.



Fig.3(a). Test setup of Slab Panel Fig.3 (b). Deflection of CW1 Fig.3 (c) Deflection of GW1 Slab



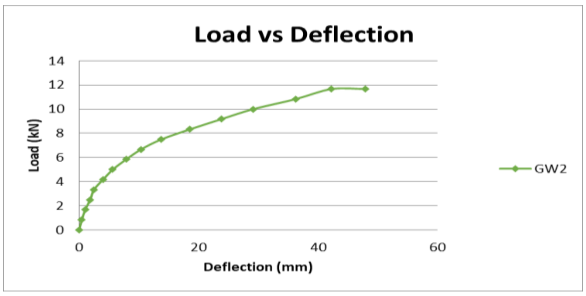


Fig.3 (d) Load Vs Deflection Curve (CW1) Fig.3 (e) Load Vs Deflection Curve (GW1)

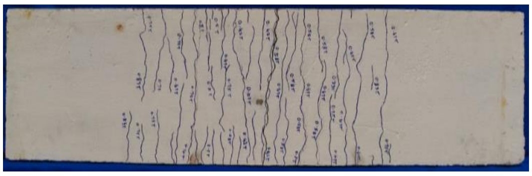


Fig.3 (f) Crack Pattern of (CW1)

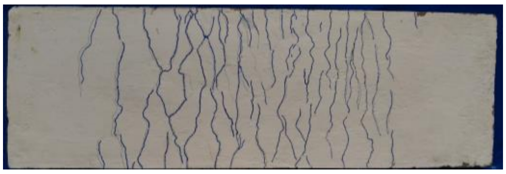


Fig.3 (g) Crack Pattern of (GW1)

4. Results and Discussions

In this study the following results are found by testing ferrocement and ferrogeopolymer slab pannel with woven mesh combined with welded and chicken mesh.

Table 3 Experimental Results of Ferrocement and Ferrogeopolymer Slabs

Specimens	Cracking Load (kN)	Ultimate load (kN)	Max. Central Deflection (mm)	Surface Cracks at Bottom		
				No. of Cracks	Avg. Spacing between cracks (mm)	Distance covered by cracks (mm)
CW1	3.33	9.17	44.6	39	29.6	554
GW1	4.17	11.67	48	37	30.5	727

5. Conclusions

- The ferrogeopolymer slab panel with woven mesh combined with welded and chicken mesh shows 25.23% increase in cracking load when compared to ferrocement slab panel with woven mesh combined with welded and chicken mesh.
- The ferrogeopolymer slab panel with woven mesh combined with welded and chicken mesh shows 27.26% increase in ultimate load carrying Capacity when compared to ferrocement slab panel with woven mesh combined with welded and chicken mesh.
- The ferrogeopolymer slab panel with woven mesh combined with welded and chicken mesh shows 7.62% increase in deflection when compared to ferrocement slab panel with woven mesh combined with welded and chicken mesh.

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