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Study on Effect of Thickness in Behaviour of Geopolymer Ferrocement Folded Panel

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Abstract: ***The exploitation of cement causes pollution to the environment and reduction of raw materials. The ordinary Portland cement requires large amount of decombustion of raw materials ensuing in considerable manifestation of CO_2. As such as geopolymer concrete have been introduced to reduce the above problem. Ferrocement is a form of reinforced concrete closely spaced multiple layers of mesh and small diameter of rods completely infiltrated with mortar. Folded structures are among the most cost effective construction they reduce the net weight of the element because of their higher stiffness in the plane of maximum bending in the direction of range. The major aim of these experimental work is to study the behaviour of geopolymer ferrocement folded panel using number of wire mesh layers by varying thickness of panel on the flexural strength by varying wire mesh layers on load deflection behaviour, ductility, ultimate flexural strength.***

Keywords: Ferrocement, Folded Panel, Geopolymer Mortar

1. Introduction

The word 'geopolymer' ɛr' was first implemented by Davidovits in 1978 to explain a family of mineral binders with chemical composition similar to zeolites but with an formless microstructure. Not like ordinary Portland pozzolanic cements, geopolymers do not shape calcium-silicate-hydrates (CSHs) for matrix formation and strength, but exploit the polycondensation of silica and alumina precursors to achieve structural strength. Ferro-cement is a relatively new building material consists of wire meshes and cement mortar. Ferrocement or ferro-cement (also called thin-shell concrete) is a scheme of reinforced mortar or plaster (lime or cement, sand and water) functional over layer of metal mesh and closely spaced thin steel rods .It is used to build relatively thin, hard, strong surfaces and structure in many shapes such as domes, shell roofs, and water tanks. Since ferrocement possess certain unique properties, such as high tensile strength-to-weight ratio, superior cracking behavior, lightweight, mold ability to any shape and certain advantages such as utilization of only locally available materials and semi-skilled labor/workmanship, it has been considered to an attractive material and a material of good promise and potential by the construction industry, especially in developing countries The parameters studied in this investigation include varying the concentration of sodium hydroxide 8 M, 10 M, 12 M, 14 M and thickness of composite panels. In this work, cement is replaced by geopolymer mix to bind the ferrocement skeletal and its' flexural behavior are studied. It is concluded that the first crack and ultimate loads increase with the increase in the thickness of the element and the concentration of alkaline solution. From the studies, it is observed that the load carrying capacities, energy absorption, deformation at ultimate load are high in the case of geopolymer ferrocement element. Further, it is observed that there is a reduction in crack width and increase in number of cracks in the case of geopolymer ferrocement indicates delay in crack growth *et.al* [1]. Geopolymer mortar specimens showed greater resistance to acid environments when compared with conventional cement mortar specimens. The geopolymer mortar specimens showed very little loss in strength and the percentage of strength loss was observed to be higher in 1:3 ratio of flyash to sand. Geopolymer mortar specimens after immersing in sulphuric acid and hydrochloric acid shows that the compressive strength are more or less same when compared to the conventional cement mortar *et.al* [2]. The experimental results show the superiority of the folded panels to the flat panel and trough panels in terms of ultimate strength and initiation of cracking. of layers of wire mesh from 1 to 2.Finally increasing the number layers significantly increases the ductility and capability to absorb energy of both types of the panel *et.al* [3]. Based upon the Experimental test results of geopolymer folded panel without and with fiber the following can be stated. Flexural strength of Geopolymer Folded Panel with Fiber is more when compared with Geopolymer Folded Panel of without fiber. The ductility of Geopolymer Folded Panel with Fiber is increased because of introduction of fiber in the mix.. The mode of failure is changed from sudden failure as exhibits in Panels without fiber because of introduction of fiber in the mix and allows sufficient time before failure after yielding *et.al* [4].

2. Experimental Study

Material Characterization

a) Fly Ash

Fly ash of class F (low calcium flyash) was collected from the Tuticorin thermal power station. The chemical composition of the fly ash, as determined by X-ray fluorescence analysis is given below. The test results were obtained from the Regional testing laboratory Madurai. The properties of fly ash are given in table 1.

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Table 1: Properties of Flyash

S.No	*Characteristics*	*% by Mass*
1	Silicon di Oxide (Sio2) plus Aluminium Oxide (Al2O3) plus Iron Oxide (Fe2O3)	95.95
2	Silica (as SiO2)	59.71
3	Magnesium Oxide (as MgO)	10.6
4	Total Sulphur as sulphur tri Oxide (Na2O)	Nil
5	Available Alkalis as sodium Oxide (Na2O)	0.63
6	Loss on Ignition	0.91
7	Moisture	0.32
8	Calcium Oxide as CaO	0.50

b) Fine Aggregate

Fine aggregate are basically sands won from the land. It is natural river sand which has been sieved to remove particles larger than 4.75 mm .The sand conforming to IS 383-1971 Zone II is used in this study. The properties of fine aggregate are given in table 2

Table 2: Properties of Fine Aggregate

S.No	*Properties*	*Results*
1	Specific gravity	2.8
2	Water absorption	1.5%
3	Fineness modulus	2.8
4	Bulk density	1843.09 Kg/m^3

c) Water

The ordinary Potable water was available in the laboratory. Specified amount of extra water was used in the mixing if needed.

d) Super Plasticizer

Super plasticizer-Conplast SP430 from FOSROC is used to improve the workability of fresh mortar. A commercially available sulphonated naphthalene formaldehyde based super plasticizer (CONPLAST SP 430) was used as chemical admixture to enhance the workability of the concrete. Color: Brown; Type: liquid; Specific gravity: 1.22-1.225 @ 300˚C.

e) Skeletal Steel

The mild steel of 6mm dia @100mm c/c both in transverse and in longitudinal direction is used as a skeletal steel.the ultimate tensile strength of mild steel is 472 N/mm^2.

f) Wire mesh

The hexagonal opening of size 12mm and wire thickness of 1.29 mm (20gauge) G.I. Wire Mesh was used. **Chicken wire mesh** is formed by twisting two adjacent wires at least four times, forming a strong honeycomb mesh structure. So, it has a high strength and durability. Therefore, subject to extreme changes in temperature, chicken wire (durable twisted woven mesh - no rigid mesh) is more acceptable for plastering than welded wire mesh or expanded metal. Its hexagonal shape prevents the formation of internal stresses. Due to its flexibility structure, chicken wire is convenient for mounting on curved and angled surfaces. Its other benefits are twisted mesh improved corrosion resistance and no risk of injury at work. As its special physical and mechanical properties, chicken wire is perfectly suited for reinforcement plastering in construction, reinforcement waterproofing, leveling floors and facade work.

g) Alkaline Solution

The alkaline liquid used was a combination of sodium silicate solution and sodium hydroxide solution. Generally the sodium hydroxides are available in solid state in the form of pellets and flakes as shown in Figure 3.2. The cost of the sodium hydroxide is mainly varied according to the purity of the substance. Since our geopolymer mortar is homogenous material and its main process to activate the sodium silicate it is recommended to use the lowest cost i.e. up to 94% to 96% purity. The properties of Sodium Hydroxide are given below:

Assay (Purity) = 97%
Carbonate(Na2co3) = 2%
Chloride (cl) = 0.01%
Sulphate (So4) = 0.05%
Lead (pb) = 0.001%
Iron (Fe) = 0.001%
Potassium (K) = 0.1%
Silicate (Sio2) = 0.05%
Zinc (Zn) = 0.02%

Sodium silicate is a versatile, inorganic chemical made by combining various ratios of sand and soda ash (sodium carbonate) at high temperature. This process yields a variety of products with unique chemistry that are used in many industrial and consumer applications.

h) Geometry of folded panel

The dimensions of folded panel is 1000 mm x 400 mm x 40 mm. The panels consist of Geopolymer Mortar and Hexagonal Wire Mesh along with skeletal steel. Fig 1 & Fig 2 shows that the geometry and cross-sections of folded panel. The cross sections of the folded panel includes single layer mesh and double layer mesh.

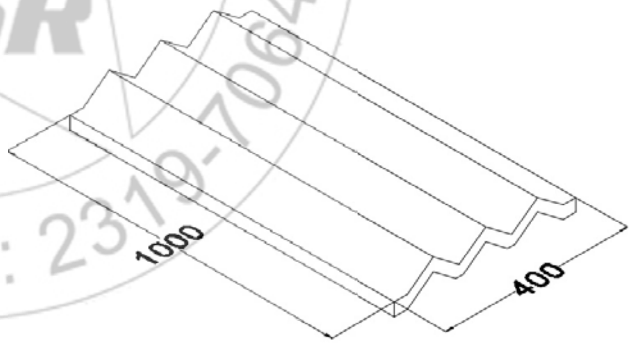

Figure 1: Geometry of Folded Panel

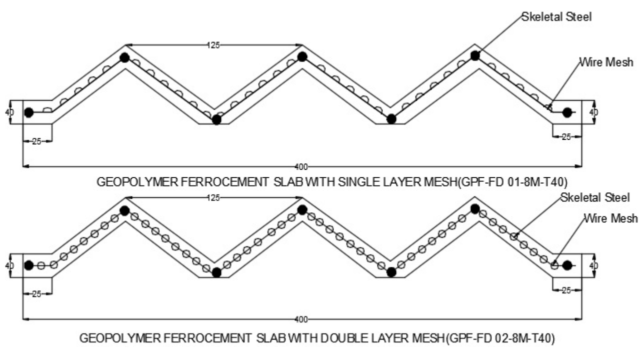

Figure 2: Cross Sections of Folded Panel

i) Mix proportions

Table 3: Mix Proportions for Geopolymer Mortar

Materials	*Proportions*
Fly Ash: Fine Aggregate	1
Super plasticizer (1% of Fly-ash)	1
Fly ash/Alkaline Solution	0.45
NaOH: Na2Sio3	1:1
Molarity of NaOH	8M

j) Casting and Curing of folded panels

The geopolymer mortar used in this study is composed of low calcium flyash and alkaline solution composed of NaOH and sodium silicate combination. NaOH is mixed with deionized water at a concentration of 8M and kept for at least 24 hours prior to casting. All the geopolymer mortar was made with sand to flyash ratio by equal proportion. The hydroxide to silicate ratio is kept constant as 1:1. The flyash and fine aggregates were dry mixed together for 5min, followed by the addition of activator solution containing hydroxide and silicate to the mixture and mixed for another 10 min. the mixing was carried out in a room temperature of approximately 25-30^{o} c.

The slab size is 1000mm (length) x 400mm (width) x 40mm (thickness) were cast in mould. The mould were made in metal such of the three side walls and one side is open from top in vertical side, all the side were detachable so that the mould could be easily separated from cast elements after its initial setting. The contact surfaces of the steel mould to the mortar were greased before casting the specimens to ease the demoulding process. The geopolymer ferrocement panel was cured in heat chamber under 80^{o}C for 24 hours.

3. Testing of Folded Panels

All the slabs are tested under loading frame. The load was applied by means of a load cell 50T. The load was applied as symmetrically arranged concentrated loads. Loading is applied using a hydraulic gauge and the dial gauge of 0.01 mm least count and 50mm range LVDT were fixed at a central bottom to measure the deflection. The slabs under painted using white cem to help in tracing the cracks. Load is applied in small range and at the same time deflection was recorded during the loading up to failure. The deflection at the mid span is measured by LVDT and cracking load also noted.

Figure 3: Test setup of GPF-FD 01-8M-T40

Figure 4: After application of load

4. Results and Discussion

The parameters that have been investigated in this study are the effect of the geometry of the panels and number of wire mesh layers on cracking load and ultimate flexural strength and plot of load deflection curve for each panel. The test results are presented in the below table, in which cracking and ultimate load for the tested ferrocement panels are summarized. The cracking load is almost constant for the folded panels and it was not affected by the number of wire mesh layers. The load deflection curves for the folded panels that increasing the number of wire mesh layers from 1and 2

Table 4: Designation of Panels

S. No	*Specimen ID*	*Description*
1	GPF-FD 01-8M-T40	Geopolymer ferrocement folded panel with single layer mesh 40mm thick
2	GPF-FD 02-8M-T40	Geopolymer ferrocement folded panel with Double layer mesh 40mm thick

Table 4: Experimental results

Specimen ID	Cracking		Ultimate	
	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
GPF-FD 01-8M-T40	3.6	4.3	9.1	34.5
GPF-FD 02-8M-T40	5	7.2	12.1	35.1

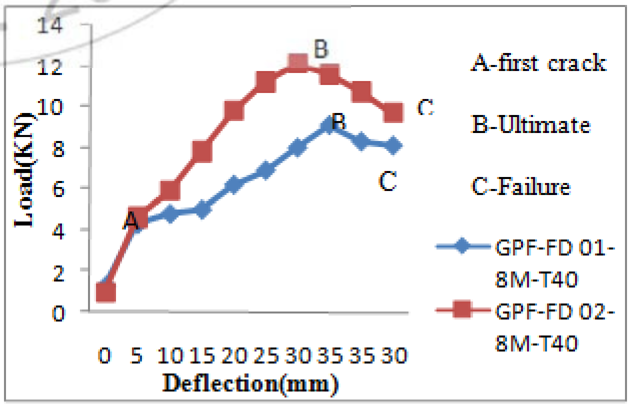

Figure 5: Load Vs Deflection Curve for GPF-FD 01-8M-T40 & GFP-FD 02-M-T40

Cracking Behavior

The failure of the geopolymer ferrocement slab specimen's results from the yielding of wire mesh reinforcement is followed by the crushing of mortar. To begin with the flexural cracks appeared at the bottom of the specimen. With further increase in the load at regularly spaced vertical cracks were observed and they extended from the bottom of the specimen towards the top (Fig.5).The load was increased up to ultimate stage and cracking pattern was noted.

Figure 6: Cracking pattern

5. Conclusions

From the Experimental results of geopolymer ferrocement folded panel

1) The flexural loads at first crack and ultimate loads depend on number of reinforcing mesh layers used in ferrocement panel
2) From the result, the flexural strength of the folded shaped panel with double layer wire mesh is higher when compared with single layer mesh.
3) The results show the advantage of the folded panels to the other type of panels in terms of ultimate strength and initiation of cracking. of layers of wire mesh from 1 to 2.
4) Increasing the thickness and number of layers of wire mesh of ferrocement panels to 40 mm significantly increases the ductility and capability to absorb energy the panels.

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