EXPERIMENTAL STUDY ON FLEXURAL BEHAVIOUR OF FIBER REINFORCED GEOPOLYMER FERROCEMENT FOLDED PANEL

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ABSTRACT

Ferrocement is a highly adaptable construction material and acquire high performance characteristics, particularly in cracking, strength, ductility, and impact resistance. The ferrocement reinforcement is uniformly distributed in both direction and closely spaced through the thickness of the section. There is abundant scope for mass production and standardization together with the economy in construction. Ferrocement is appropriate for low-cost roofing, precast units and manhole covers. It is also used for the construction of domes, water tanks, boats, silos and folded plates. Geopolymer is an innovative revolutionary green material. An experimental investigation on ferrocement folded panel with geopolymer mortar and polypropylene fiber has been conducted for various mix proportions and fiber ratio. The results show that the flexural strength of the folded panel increased with the addition of fiber and also concluded that the addition of fibers increased the ductility and decreased the crack development and spilling of cement matrix.

Key Words: Fiber, Ferrocement, Folded Panel, Geopolymer Mortar,

I. INTRODUCTION

Geopolymers are a class of new binder generally manufactured by activating an alumino silicate source material in a highly alkaline medium. For the production of concrete-the most widely used construction material in the world, Ordinary Portland Cement (OPC) is the main ingredient used which is among the most energy intensive construction material and whose production is for an increase of 3% annually [1]. The production of OPC releases large amount of carbon dioxide (CO_2) to the atmosphere that significantly contributes to greenhouse gas emissions. One ton of CO_2 is released into the atmosphere for every ton of OPC produced [2]. Therefore, there is a need to find an alternative type of binder to produce more environmentally friendly mortar. A promising alternative is the replacement of cement with by product material such as fly ash.

Ferrocement is a highly adaptable form of reinforced concrete. Ferrocement is a building material together of a relatively thin layer of concrete, covering such reinforcing material as steel wire mesh. The ferrocement has unique properties such as good tensile strength, toughness, water tightness, fire resistance, resistance to cracking.

II. EXPERIMENTAL STUDY

2.1 Material Characterization

2.1.1 Fly ash

Fly ash of Class-F obtained from the Tuticorin Thermal Power Plant is used throughout this study. The chemical composition of the fly ash, as determined by X-ray fluorescence analysis is given below.

Table 1: Chemical Compositions Fly Ash

S. No.	Characteristics	% by mass
1	Silicon di Oxide (Sio_2) plus Aluminium Oxide (Al_2O_3) plus Iron Oxide (Fe_2O_3)	95.95
2	Silica (as SiO_2)	59.71
3	Magnesium Oxide (as MgO)	106
4	Total Sulphur as sulphur tri Oxide (Na_2O)	Nil
5	Available Alkalis as sodium Oxide (Na_2O)	0.63
6	Loss on Ignition	0.91
7	Moisture	0.32
8	Calcium Oxide as CaO	0.50

2.1.2 Fine Aggregate

Sand obtained from Trichy River passing through IS Sieve of 4.75mm and having a Fineness Modulus 2.80 and Specific Gravity 2.62 conforming to IS 383-1971 Zone II is used in this study.

2.1.3 Water

Specified amount of extra water was used in the mixing. The ordinary Potable water was available in the concrete laboratory used for the purpose.

2.1.4 Super Plasticizer

Super plasticizer-Conplast SP430 from FOSROC is used to improve the workability of fresh mortar.

2.1.5 Fiber

Recron 3s was used in this study for making the fiber reinforced Geopolymer folded panel. Recron 3s fiber has more advantages, such as increased ductile property, reduction in water permeability, and increased in flexibility, high Melting point. Low cast and easily disperses in the cement matrix. Table: 2 shows the properties of Polypropylene Fiber (Recron 3s).

Fig: 1 Polypropylene Fiber (Recron 3S)

Table 2 Properties of Polypropylene Fiber (Recron 3S)

S. No.	Properties	Specifications
1	Effective Diameter	10µ - 1.0 mm
2	Length	6 – 12 mm
3	Specific Gravity	0.91 Kg/m^3
4	Water Absorption	Less than 0.45 %
5	Melting Point	Not less than 160° C
6	Aspect Ratio	12

2.1.5 Skeletal Steel

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

2.1.6 Wire Mesh

G.I. Wire Mesh with hexagonal openings of size 12mm and wire thickness of 1.29 mm (20gauge) was used.

2.1.7 Sodium Hydroxide (NaOH)

The properties of Sodium Hydroxide are described below:

Assay (Purity) = 97%
Carbonate(Na_2co_3) = 2%
Chloride (cl) = 0.01%
Sulphate (So_4) = 0.05%
Lead (pb) = 0.001%
Iron (Fe) = 0.001%
Potassium (K) = 0.1%
Silicate (Sio_2) = 0.05%
Zinc (Zn) = 0.02%

2.1.8 Sodium Silicate (Na_2 SiO_3)

Sodium Silicate, usually known as “water glass" or “liquid glass”, is well-known due to wide commercial and industrial applications. It is mostly composed of oxygen-silicon polymer backbone lodging water in molecular matrix pores. Sodium silicate products are manufactured as solids or thick liquids, depending on proposed use.

2.2 Geometry of Folded Ferrocement Panel

The geometry of ferrocement panel is folded shape with dimensions of 1000 mm x 400 mm x 30 mm. The reference number and designation of the panels are given in Table 6. The panels are constructed using the conventional ferrocement materials, which is composed of Geopolymer Mortar and Hexagonal Wire Mesh along with skeletal steel. Fig 2 & Fig 3 shows the geometry and cross-sections of folded panel.

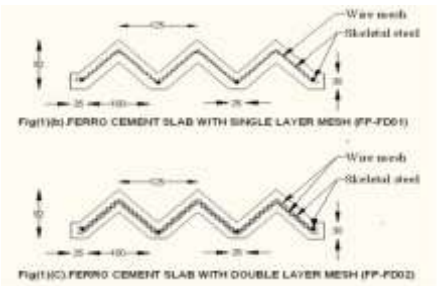

Fig: 2 Cross Sections of Folded Panel

Fig: 3 Geometry of Folded Panel

2.3 Mix Proportions

Table: 3 Mix Proportions for Geopolymer Mortar

Materials	Percentage of Polypropylene fiber	
	0.0%	**0.4%**
Fly Ash: Fine Aggregate	1	**1**
Super plasticizer (1% of Fly-ash)	1	**1**
Fly ash/Alkaline Solution	0.45	**0.45**
NaOH:Na_2Sio_3	1:1	**1:1**
Molarity of NaOH	8M	**8M**

2.4. Preparation of Control Specimens

Geopolymer Mortar cubes of size 70.6mm × 70.6 mm× 70.6 mm were cast to characterize strength of the mortar using the mix proportions as described in Table:3 and then cured @70˚ C for 24 hours in the heat curing chamber [3].

Fig. (4) Control specimens

2.5 Casting and Curing of Folded Panels

The required geometry of the folded panel was made using steel mould fabricated to match the shape and size. Each sample was cast after fixing the required wire mesh and meshes in its proper position in the mould [4]. For the panels with single wire mesh, the mesh was placed at mid depth of the panel and the mortar mix was prepared using Sand-Fly ash ratio and Alkaline Solution-Fly ash ratio by weight of 1:1 and 0.45, respectively. After 24 hours from casting, the samples are removed from the mould and the cured in 24 hours

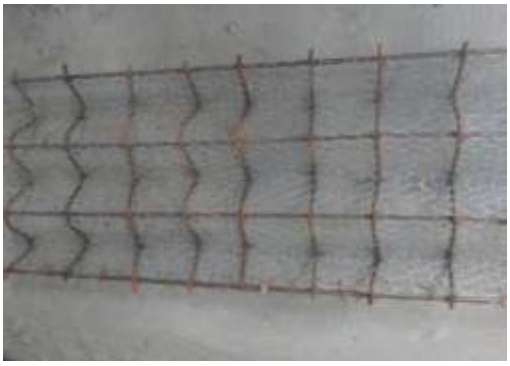

Fig: 5 Reinforcement Details Of Panel

Fig:6 Curing Of Panel In Heat Chamber

III. TESTING OF FOLDED PANELS

After curing, the slabs are tested under loading frame. The load was applied by means of a load cell 20T. The specimens were tested by simulating simply supported conditions. The load was applied as two symmetrically arranged concentrated line loads. Loading was applied using a Hydraulic Jack and LVDT was fixed at central bottom to measure the deflection. The slabs were painted using whitecem to help in tracing the cracks. The test setup of the tested trough panel is shown in figure. The load is applied in small increments and simultaneously the deflection at the center of the panel was recorded during the loading process up to failure. The deflection at the mid span is measured by LVDT (0 to 50mm). Cracking was carefully checked throughout the loading process and the corresponding cracking load is also noted. The test results were interpreted using Universal Digital Data Acquisition System interface with PC and Application Software.

Fig: 7 Loading Setup

Fig 8. During Application of Load

IV. RESULTS AND DISCUSSION

Table 4 Designation of Panels

S. No.	Specimen ID	Description
1	GFP-FD-01	Geopolymer Ferrocement Panel with single layer Mesh
2	FRGFP-FD 01	Fiber reinforced-Geopolymer Ferrocement Panel with single layer Mesh

Fig.9 shows Load Vs Deflection of Geopolymer Folded Panels of without (GFP-FD-01) and with fiber (FRGFP-FD 01). From that, GFP-FD-01 specimen was deflected suddenly without any caution [7]. The first crack was formed under the load. The time taken to first crack to ultimate failure is too short. So the failure of the specimen was rapidly. In FRGFP-FD 01the specimen was deflected after the sufficient formation of cracks [8]. The first crack also was formed under the load and the elapsed time between failures to ultimate is too long. The above failure of the specimen was restricted by evenly distributing the fiber in tension zone. Table: 5 & Table: 6 shows Load Vs Deflection of the specimens.

Table.7 & 8 shows the Stiffness of Geopolymer Folded Panels of without (GFP-FD-01) and with fiber (FRGFP-FD 01). From the Fig. 10, the Stiffness of the GFP-FD-01 specimen was higher than the FRGFP-FD 01. Because of fiber has the resilient property, due to that the stiffness of the matrix was good. Table 9 &10 shows the Ductility of Geopolymer Folded Panels of without (GFP-FD-01) and with fiber (FRGFP-FD 01). From Fig: 11 the Ductility of the GPFP2A specimen was higher than the GFP-FD-01. Because of the introduction of fiber in FRGFP-FD 01.

Table 5 Load Vs Deflection of GFP-FD-01

S.No	Load (KN)	Deflection (mm)
1	0	0.1
2	1	0.5
3	1.5	0.6
4	2.3	0.9
5	2.8	1.1
6	3.5	1.2
7	4.0	1.4
8	4.3	1.7
9	4.8	1.9
10	5.0	2.2
11	5.3	2.4
12	5.8	2.7
13	6.0	3.0
14	6.4	3.3
15	6.8	3.9
16	7.0	4.6
17	6.7	5.0
18	6.6	7.1
19	6.5	7.9
20	5.8	35.9
FCL		6.0
UL		7.0

Table: 6. Load Vs Deflection of FRGFP-FD 01

S.No	Load (KN)	Deflection (mm)
1	0	0.1
2	0.4	1.4
3	0.6	2.8
4	1.2	3.8
5	1.6	4.5
6	2.1	5.6
7	2.5	6.9
8	3	8.0
9	3.4	10.7
10	4.2	13.2
11	4.8	14.6
12	5.6	15.9
13	6.1	17.3
14	6.4	18.8
15	6.9	20.6
16	7.5	22.1
17	7.9	23.5
18	8.6	25.3
19	9.6	29.9
20	8.2	35.7
21	8.1	38.9
22	6.87	49.3
FCL		3.0
UL		9.6

Table: 7 Load Vs Stiffness of GFP-FD-01

S.No	Load Sequence	Stiffness (KN/mm)
1	1	2.91
2	2	2.85
3	3	2.52
4	4	2.27
5	5	2.2
6	6	2.14
7	7	2
8	8	1.9
9	9	1.74
10	10	1.66
11	11	1.52
12	12	1.34
13	13	1.22
14	14	1.07
15	15	0.97
16	16	0.92
17	17	0.91
18	18	0.86

Table: 8 Load Vs Stiffness of FRGFP-FD 01

S.No	Load Sequence	Stiffness (KN/mm)
1	1	0.38
2	2	0.36
3	3	0.35
4	4	0.34
5	5	0.33
6	6	0.30
7	7	0.27
8	8	0.23
9	9	0.19
10	10	0.16
11	11	0.15

Table: 9 Load Vs Ductility For GFP-FD-01

S.No.	Load Sequence	Ductility
1	1	0.03
2	2	0.15
3	3	0.18
4	4	0.27
5	5	0.33
6	6	0.36
7	7	0.42
8	8	0.51
9	9	0.57
10	10	0.66
11	11	0.72
12	12	0.81
13	13	0.9
14	14	1
15	15	1.18
16	16	1.27
17	17	1.39
18	18	1.51
19	19	1.6
20	20	1.81
21	21	2.03
22	22	2.15
23	23	2.21
24	24	2.3

Table: 10 Load Vs Ductility For FRGFP-FD 01

S.No.	Load Sequence	Ductility
1	1	0.18
2	2	0.35
3	3	0.56
4	4	0.86
5	5	1
6	6	1.34
7	7	1.65
8	8	1.98
9	9	2.16
10	10	2.58
11	11	2.93
12	12	3.73
13	13	4.86
14	14	5.36
15	15	5.58
16	16	6.16

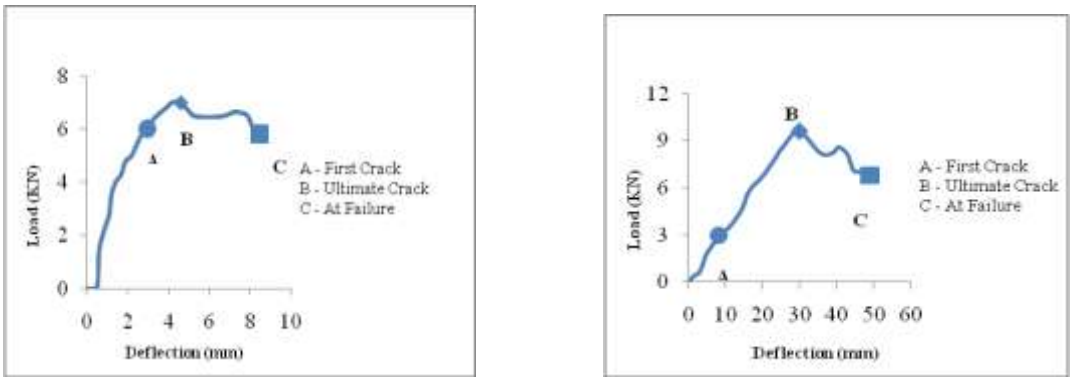

Fig :9 Load Vs Deflection Curve for GPF-FD 01 & FRGFP-FD 01

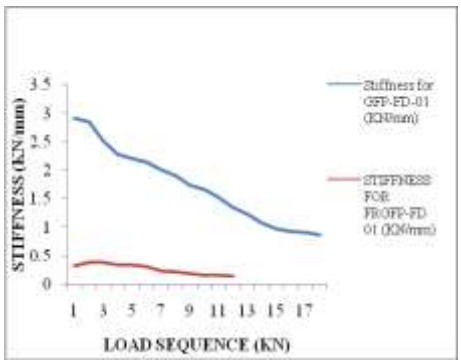

Fig : 10 Load Vs Stiffness Curve for GPF-FD 01 & FRGFP-FD 01

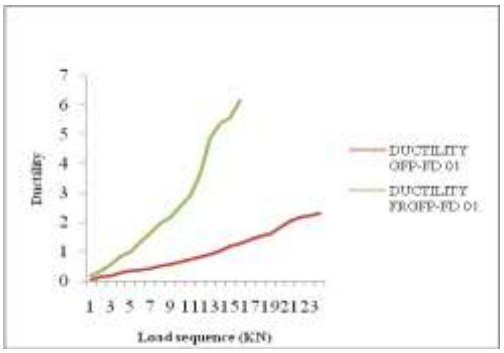

Fig: 11 Load Vs Ductility Curve for GPF-FD 01 & FRGFP-FD 01

V. CONCLUSIONS

Based upon the Experimental test results of geopolymer folded panel without and with fiber the following can be stated.

1. Flexural strength of Geopolymer Folded Panel with Fiber is more when compared with Geopolymer Folded Panel of without fiber.
2. The ductility of Geopolymer Folded Panel with Fiber is increased because of introduction of fiber in the mix..
3. 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.

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BIOGRAPHICAL NOTES

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