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Research Article

FLEXURAL BEHAVIOUR OF FERRO CEMENT SLAB PANELS USING CARBON FIBERS

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ABSTRACT

Ferro cement is one of the earliest versions of reinforced concrete. In this, an attempt has been made to find out the flexural behavior of Ferro cement experimentally and analytically. The slab panels of size (700 mm × 600 mm) with a thickness of 30 mm were casted with a cement motor of mix proportion (1:2) and the water-cement ratio of 0.40. Some panels were casted with carbon fibers of 1% of total volume cement. The variation is shown by increasing the mesh layer and addition of the carbon fibers. The slab panels are tested under the two point loading system after curing period. The analysis is carried out by ansys R15.0 software and comparison of results has been done. The test result shows that the slab panels with more number of mesh layers exhibit less deflection and more flexural strength when compare to the slab with less number of mesh layers.

INTRODUCTION

Ferro cement is the one of the earliest version of reinforced concrete, however its design has been mostly empirical and design guides have not been developed. The Ferro cement concrete was introduced in 1852, from that point of time mortar matrix has been widely used as major constituent material of the versatile system and typically reinforced with flexible woven wire mesh or welded wire mesh. It is a new construction material which may be used for building light structures. These thin elements can be shaped to produce structural members such as folded plates, flanged beams, wall panels etc., the reinforcing mechanism in Ferro cement not only improves many of the engineering properties of the brittle mortar, such as fracture, tensile and flexural strength, ductility, and impact resistance.

In the earthquake-resistant design of structures, over strength and ductility are key factors that influence safety. Ductility of the whole structure depends on the ductility of each individual member, for example beams, columns, or floors.

It also depends on the configuration of the structure. Ferro cement elements are generally more ductile when compared to conventional reinforced concrete elements. It has a very high tensile strength-to-weight ratio and superior cracking behavior when compared with reinforced concrete. The Ferro cement structures can be made relatively thin, light and water-tight when compare with the reinforced concrete structures (Phalke and Gaidhankar, 2014; Deepa Shri and Thenmozhi, 2012; Mahmood and Majeed, 2009).

MATERIAL SPECIFICATION

The materials used in this experimental study are according to the IS specifications. Ordinary Portland cement of 53 grade having specific gravity 3.16, fine aggregate of zone II river sand having a specific gravity of 2.67 and potable water is used. The welded

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square mesh is used as the reinforcing material for the slab and the properties are tabulated below in Table 1.

EXPERIMENTAL STUDY

Mix proportion factor, M40 grade has been chosen for this study. While casting the slabs cement mortar cubes of standard size 70.6 mm × 70.6 mm × 70.6 mm were used. Cement mortar with cement sand ratio 1:2 and water cement ratio of 0.4 by weight of cement and 1% of carbon fibers were used for casting slabs. The average compressive strength of cubes are tabulated below in Table 2.

Total of four specimens were casted of with and without carbon fibers were casted are shown below in the Fig. 1.

Two point loading was applied on the casted specimens and the axial deformations are taken from the dial gauges and the experimental setup were shown in the Fig. 2.

ANALYTICAL STUDY

Finite Element Modelling

The specimen is simply supported on two sides of size 700 mm × 600 mm × 30 mm was modeled, Solid 65 is used for the three-dimensional modeling of solids with or without reinforcing bars. The solid is capable of cracking in tension and crushing in compression. The link8 is used for the reinforcement. The three-dimensional spar element is a uniaxial tension-compression element with three degrees of freedom at each node which may be used in a variety of engineering applications element was used for the reinforcement of slab with mesh layers (Ban and Ramli, 2010; Gaikwad and Attar, 2014). The slab models are shown in the below (Fig. 3).

Table 1. Mechanical properties of the wire mesh

Elastic Modulus	2×10^5 N/mm^2
Poisson's ratio	0.3
Yield strength	250 N/mm^2
Ultimate strength	415 N/mm^2
Diameter of the wire mesh	1.26 mm
Spacing of the mesh	15 m

Table 2. Compressive strength of the cubes

Without carbon fibers				
S.no.	**Size (mm)**	**Load (N)**	**Compressive Strength (N/mm^2)**	**Average Compressive Strength (N/mm^2)**
1	70.6 × 70.6	201000	40.32	40.58
2	70.6 × 70.6	205000	41.12	
3	70.6 × 70.6	201000	40.32	
With carbon fibers				
4	70.6 × 70.6	221000	44.33	44.33
5	70.6 × 70.6	224000	44.94	
6	70.6 × 70.6	218000	43.73	

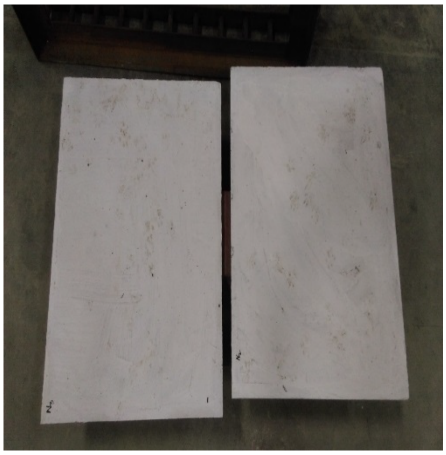

Fig. 1 Casted slab panels.

Fig. 2 Experimental setup of slab specimen.

Boundary Conditions

The slab is simply supported and is retrained in all the directions and the load is applied at distance of L/3 from the edges of the slab are shown in (Fig. 4).

The Deformed shapes of slab are shown in the below (Fig. 5).

RESULTS

The Experimental and analytical results are tabulated and the graphs are drawn below.

Experimental Results

The Experiment results are tabulated below in Table 3.

The load vs. Deflection graph of slab panels with and with out carbon fiberrs are shown in the (Fig. 6).

The load vs. deflection values of slab with 3 mesh layers are tabulated below in the Table 4.

Load vs. deflection graph of 3 mesh layers with and without fibers are shown below in the (Fig. 7).

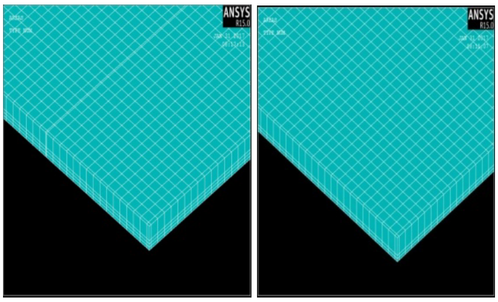

Fig. 3 Analytical model of slab.

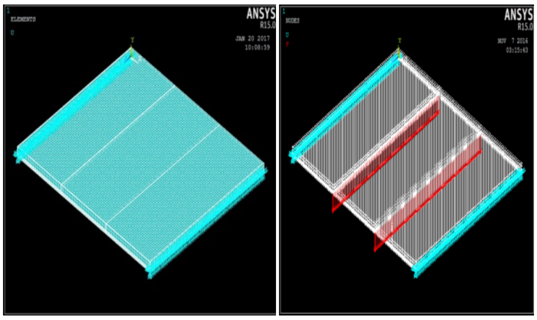

Fig. 4 Ferro cement slab with boundary conditions and application of load.

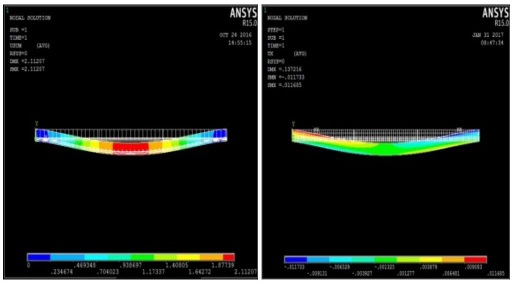

Fig. 5 Deformed shapes of the slab.

Table 3. Two mesh layered slab with and without fibers

Load (N)	Without fibers	with fibers
	Deflection(mm)	Deflection(mm)
0	0	0
2000	1.08	0.9
4000	2.53	2.24
6000	4.28	3.51
8000	7.18	5.26
10000	10.86	7.25
12000	--	9.75

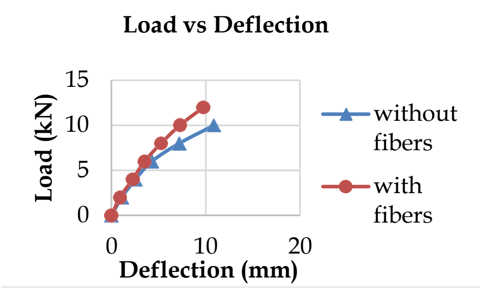

Fig. 6 Load vs. deflection graph of two mesh layered slab.

Analytical Results

The analytical results of 2 mesh layers with and without fibers are tabulated below in Table 5.

The load vs. deflection graph of analytical results with 2 mesh layers of Ferro cement slab is shown below in the (Fig. 8) (Aboul-Anen, *et al*., 2009; Reddy and Halhalli, 2015; Bhairavkar, *et al*., 2013).

The analytical Results of 3 mesh layers with and without fibers are tabulated below in Table 6.

The load vs. deflection graph of slab panel with 3 mesh layers with and without fibers are shown below in the (Fig. 9).

The Flexural strength of two meshes layered and three mesh layered slab of experimental values are tabulated below in Table 7.

Table 4. Three mesh layered slab with and without fibers

Load (N)	Without fibers	With fibers
	Deflection (mm)	Deflection (mm)
0	0	0
2000	0.97	0.72
4000	1.88	1.58
6000	3.17	2.43
8000	4.53	3.54
10000	5.89	4.85
12000	7.29	6.39
14000	8.92	8.22
16000	--	10.75

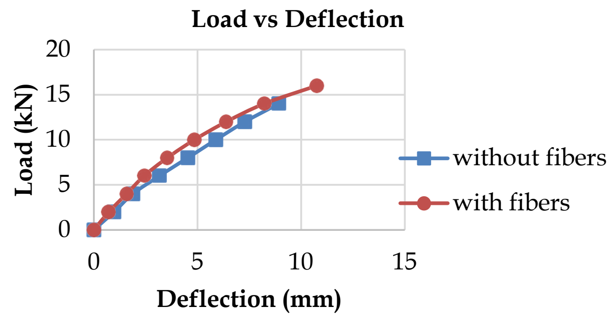

Fig. 7 Load vs. deflection graph of three mesh layered slab.

Table 5. Two mesh layered slab with and without fibers

Load (N)	Without fibers	With fibers
	Deflection (mm)	Deflection (mm)
0	0	0
2000	0.23	0.13
4000	0.51	0.31
6000	0.84	0.58
8000	1.21	0.91
10000	1.65	1.36
12000	2.11	1.82
14000	--	2.36

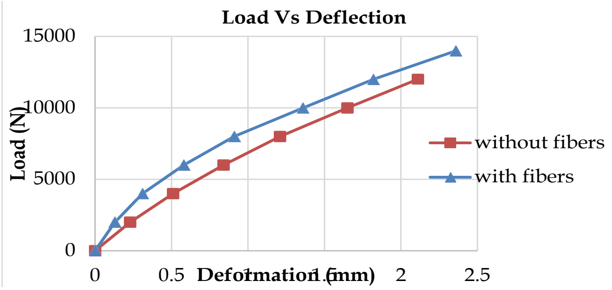

Fig. 8 Load vs. deflection graph of two mesh layered slab.

Table 6. Three mesh layered slab with and without fibers

Load (N)	Without fibers	With fibers
	Deflection (mm)	Deflection (mm)
0	0	0
2000	0.26	0.15
4000	0.45	0.36
6000	0.67	0.55
8000	1.06	0.93
10000	1.45	1.26
12000	1.87	1.61
14000	2.33	1.96
16000	2.97	2.45
18000	---	2.86

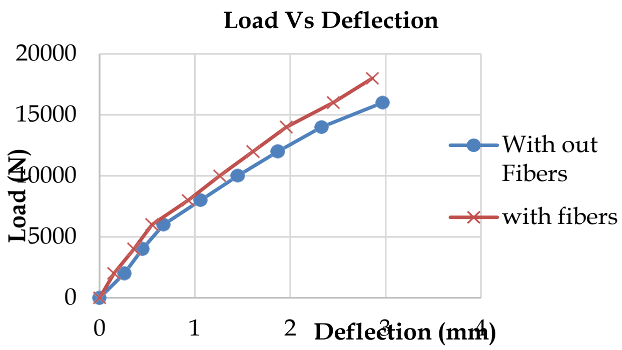

Fig. 9 Load vs. deflection graph of three mesh layered slab.

Table 7. Flexural strength of experimental values

Description	Analytical Flexural Strength (N/mm²)	Experimental Flexural Strength (N/mm²)
Slab with 2 mesh layer without carbon fibers	9.65	12.95
Slab with 2 mesh layer with carbon fibers	10.34	15.55
Slab with 3 mesh layer without carbon fibers	12.45	18.21
Slab with 3 mesh layer with carbon fibers	14.89	20.67

CONCLUSION

1. By the increase of the mesh layers there is an increase of 52% increase in flexural strength.

2. By the increase of the mesh layers there is an increase of 10% in the stiffness.

3. By the addition of fibers there is an increase of 28% in the stiffness.

4. By the Addition of fibers there is an increase in load carrying capacity.

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