

Effect of Different Types of Fibers on the Flexural Strength of Ferrocement Panels

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ABSTRACT: The present study describes the results of testing flat ferrocement panels reinforced with different numbers of woven mesh layers and three different types of steel fiber, for the mix that replaces river sand with crush sand. The main objective of this work is to study the effect of using woven wire mesh as reinforcement along with different types of steel fibers on the ultimate flexural strength of ferrocement panels. The number of layers used were minimum of 2. Panels were casted with mortar mix ratio (1:1.5) and water cement ratio (0.4) including super plasticizer (Perma Ps-34) with dosage of 1.5% by weight of cement. Panels were tested under two point loading system under UTM machine after curing period of 28 days. Test results shows that panels combined with hooked end fibres exhibits greater flexural strength and less deflection as that compared with panels having less mesh layers and other steel fibers. The energy absorption of these panels were also studied through impact test. The results showed that the addition of fibers increased the first crack load and ultimate failure load for all types of fibres.

KEYWORDS: Ferrocement, Wire mesh, Fibres, Two point Loading, Flexural Strength.

I. INTRODUCTION

The history of ferrocement, as narrated by Cassie, dates from the construction of 11.5ft rowing boats by Lambot in France in 1848, made of cement mortar reinforced with parallel rows of steel bars interwoven in two directions at right angles. Development of the present day form of ferrocement, mortar reinforced with wire mesh, chicken wire, or expanded metal instead old bars, is largely due to Nervi. Ferrocement provides an economically viable alternative to traditionally used RCC and steel construction. Ferrocement is considered an environmentally sound technology .Although it is about 170 years old, numerous application worldwide. In order to maintain efficient serviceability, older structures must be repaired or strengthened so that they meet the same requirements demanded of the structures built today and in future. Ferrocement over the years have gained respect in terms of its superior performance and versatility. This study explores effect of different types of fibers on the strength of ferrocement panels.

II. LITERATURE REVIEW

Antoine E .Naaman^[2]*et al-* In this paper, investigation on ferrocement thin plates reinforced by two types of low cost expanded steel meshes and one Kevlar FRP mesh, as well as a two types of synthetic discontinuous short fibers ,namely spectra and PVA fibers are reported. Results of the control specimen without fiber are also presented for comparison. MORs were further predicted by theoretical models, and good agreement was observed. Experimental program: The main parameters investigated in this project include the type of mesh, the volume fraction of reinforcement and the addition of discontinuous fibers. Two types of gage 20 expanded steel meshes and one type of Kevlar FRP mesh were studied. Two types of polymeric fibers namely PE spectra 900 fiber and Poly Vinyl Alcohol(PVA) fiber are investigated in combination with different mesh reinforcements Eight series totaling 24 ferrocement plate specimens were prepared and tested under four point bending the specimens measure

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304.8mm(L)x7602mm(W)x12.7mm(H) with various combinations of mesh ,matrix and fibers for the specimens.

S. DeepaShri^[9] *et al* - In this paper, carried out an experimental work on ferrocement panels for studying their flexural behaviour by using polypropylene fibers. The authors conclude that the load carrying capacity of SCC ferrocement slab panel with 0.3% fibers is larger compared to without fibers, delayed the first crack load, yield load and ultimate load compared to without and there is an increase in strength with the increase of slab thickness. Hybrid reinforced ferrocement specimens could sustain the larger deflections both at yield and ultimate loads compared to the SCC ferrocement specimens without . Many micro cracks are formed before failure of the specimens, indicating more energy absorption and ductility, the stiffness of the specimens with 2-layers bundled weld mesh is lower than that of the specimens with 3 layers bundled.

JacekKatzner ,JacekDomski^[5] *et al* - The main purpose of this paper is to check the quality and mechanical properties of a commercially available and commonly used steel fiber. The paper outlines the research program carried out that was divided into three main stages. The first stage covered measurements of geometrical dimensions of fibre such as: length, diameter, length of endings, length of a slope and angle of a hook 2.The second stage covered tests of tensile strength of fibre. The test was performed with controlled (constant rate) increase of force.

III. AIM AND OBJECTIVES

The main aim and objective of this experimental work is to study the behaviour of ferrocement panels under flexural loading in which woven square mesh will be used as a reinforcement and three different types of fibers have been used in addition to reinforcement. The main parameters considered in this study are effect of different types of steel fibers and the effect of panel thickness on the flexural strength of ferrocement panels.

IV. EXPERIMENTAL RESULTS

The experimental program includes preparing and testing of flat ferrocement slab panels under two-point loading. The primary variables were the number of layers of meshes in panels and the use of steel fibers.

Materials used -:

Cement Ordinary Portland Cement (Grade 53),Crushed Sand -:-Passing through 2.36 mm I. S. Sieve, Admixture (Perma Plast PS-34) Water – Ordinary Drinking Water, Mesh Used – Woven wire Square Mesh of 1.6 mm Diameter($E = 138\text{MPa}$, $\sigma_y = 415\text{MPa}$). Steel fibers of three types hooked end fibers, flat crimped Fibers and corrugated type fibers.

Mix proportion used:-

Cement sand ratio (1:1.5).Water cement ratio (0.4). Cubes of size (70*70*70 mm) of above proportion were casted with 03 different types of steel fibers. Compressive strength is obtained at 28 days and is tabulated below. As per the decided proportion, 09 nos. of mortar cubes are prepared for each type of fibres. These are kept in the water for 28 days for curing. Cubes of each type are tested under compression testing machine and compressive strength obtained at the age of 28 days is presented in the table given below.

Table.1. Compressive strength at the age of 28 days
Size of cube:70 mmx70 mmx70mm

Sr. .No.	Type of fibers	Compressive Strength (MPa)
1	Panels without fibers	50
2	Panels with Hooked fibers(H1)	58.5
3	Panels with Flat crimped fibers(Cr1)	56
4	Panels with Corrugated fibers(E1)	65

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C. Preparation of mortar:-

Mortar was prepared by calculating the exact amount of cement, sand and water. First the cement and sand were mixed dry. Admixture with dosage of 1.5% by weight of cement was mixed thoroughly with water and then added to dry mix. Steel fibers with dosage of 1% of volume of panels were added.

D. Casting:-

The steel Moulds prepared were properly oiled before casting. At bottom a layer of mortar was applied of thickness 3 mm followed by layer of welded square mesh and again followed by layer of mortar. The procedure continues for placing layers of mesh in panel. The mesh pieces were cut down according to the size of panel leaving a cover of 3 mm on both side of mesh. The specimens were kept in water for 28 days for curing.

E. Testing:-

The panels were removed from the curing tank after a period of 28 days. White wash was applied to the panels to get clear indication of the cracks due to bending under service load. Panels were tested for flexure test under Universal testing machine. The panels were placed on support leaving a space of 50 mm from both ends. Dial gauge was placed below the panel to record the deflection in mm at each stage of loading. The ferrocement panels were loaded under two point loading and loads and corresponding deflections were noted down.

The flexural strength was calculated using the following formula,

$$M/I = \sigma/y, \text{ thus } \sigma = M/I * y$$

Where:

M = Bending Moment (N.mm), y= D/2 (mm), I = Moment of Inertia= bd³/12.

Numerical Approach :-

Cracking moment calculation:

$$I_{(tr)uncracked} = \frac{bh^3}{12} + (n-1) \sum A_{ri} \left(\frac{h}{2} - d_i\right)^2$$

$$M_{Cr} = \frac{2X\sigma_m I_{(tr)uncracked}}{h}, \quad E_c = E_M \cdot V_m + E_r \cdot V_{rL}$$

Maximum service moment and corresponding curvature,

$$\frac{bC^2}{2} + 39CA_{ri} - 238.5A_{ri}$$

$$I_{(tr)cracked} = \frac{bC^2}{3} + (n-1)A_{r1}(C - d_1)^2 + n.A_{r2}(d_2 - C)^2 + nA_{r3}(d_3 - C)^2 + nA_{r4}(d_4 - C)^2$$

Service moment calculation:

$$\sigma_{ri} = n \frac{M_{ser} \cdot (d_i - C)}{I_{(tr)cracked}}, \quad \sigma_{mtop} = \frac{M_{service} \cdot X C}{I_{(tr)cracked}}$$

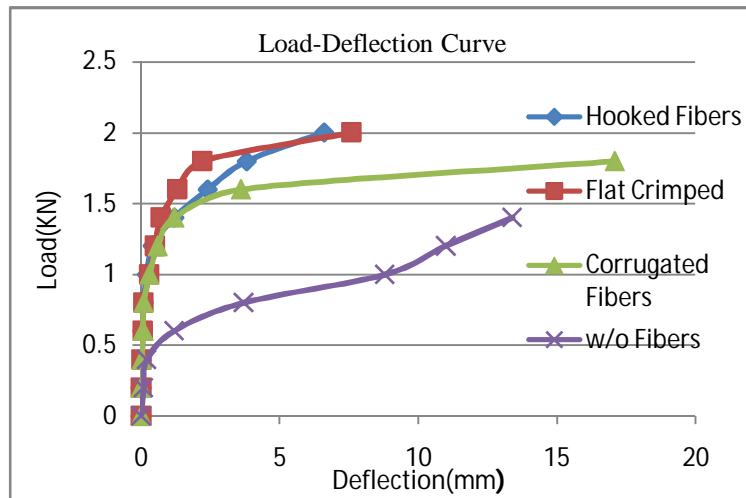
The main parameters that had been investigated in this study is the combined effect of different types of steel fibers with two number of woven wire mesh layers on the cracking load and the ultimate flexural strength and to plot the load verses deflection curve for each panel. The test results of the specimen tested at the age of 28 days from the date of casting are presented.

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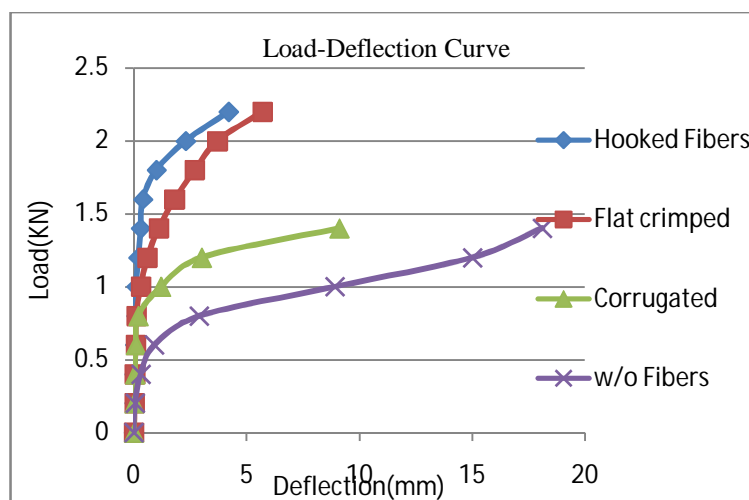
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Fig.1 Load Vs Deflection Curves for 550mm x200mm x20mm ferrocement panels.



Ferrocement panels of 20 mm thickness was prepared using 02 layers of mesh. The meshes are placed such that, the top mortar cover was be 03 mm and the bottom mortar cover was about 4 to 5 mm. For each category 03 nos. of panels were prepared. The panels were placed in the water for 28 days for curing. After 28 days, the panels were tested under Universal Testing Machine. During the testing, the loads and the corresponding deflections were recorded. The average results has been represented in the graph shown above.

Fig.2 Load Vs Deflection Curves for 750mm x200mm x 30 mm ferrocement panels.



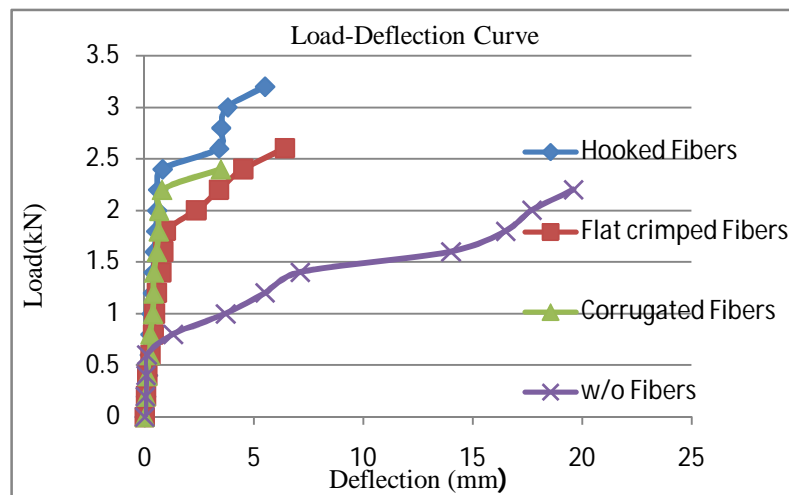
Ferrocement panels of 30 mm thickness was prepared using 02 layers of mesh. The meshes are placed such that, the top mortar cover was be 03 mm and the bottom mortar cover was about 4 to 5 mm. For each category 03 nos. of panels were prepared. The panels were placed in the water for 28 days for curing. After 28 days, the panels were tested under Universal Testing Machine. During the testing, the loads and the corresponding deflections were recorded. The average results has been represented in the graph shown above.

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Fig.3 Load Vs Deflection Curves for 900mm x200mm x 40 mm ferrocement panels.



Ferrocement panels of 40 mm thickness was prepared using 02 layers of mesh. The meshes are placed such that, the top mortar cover was be 03 mm and the bottom mortar cover was about 4 to 5 mm. For each category 03 nos. of panels were prepared. The panels were placed in the water for 28 days for curing. After 28 days, the panels were tested under Universal Testing Machine. During the testing, the loads and the corresponding deflections were recorded. The average results has been represented in the graph shown above.

Table.2 Flexural strength for Ferrocement Panels

Sr. No.	Type of Fibers Used	Size of specimen	Flexural strength (MPa)	
			Experimental	Analytical
1.	Without Fibers	550x200x20mm	12.18	10.30
2.		750x200x30mm	08.71	07.50
3.		900x200x40mm	07.78	06.70
4.	Hooked Fiber	550x200x20mm	22.50	19.00
5.		750x200x30mm	15.89	13.50
6.		900x200x40mm	16.00	13.00
7.	Flat Crimped Fibers	550x200x20mm	22.50	19.00
8.		750x200x30mm	15.89	13.50
9.		900x200x40mm	13.00	11.05
10.	Corrugated Fibres	550x200x20mm	20.25	17.20
11.		750x200x30mm	10.11	08.59
12.		900x200x40mm	12.00	10.00

The ferrocement panels prepared were tested under Universal Testing Machine using two point loading. The panels are tested till the specimen reaches its ultimate stage and the final load at failure has been recorded. For each category, 03 nos. of panels were tested and final load at failure has been recorded. The flexural strength shown in the above table is the average flexural strength at the final failure load. The flexural strength is also obtained analytically and the same has been presented in the above table.

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V. CONCLUSION

Based on experimental results following conclusions are laid down -:

1. The experimental results shows that addition of fibers increases the flexural strength of ferrocement panels.
2. The flexural loads at first crack and ultimate loads also increase due to addition of steel fibers.
3. For 20 mm thick panels, 72% increase in flexural strength for ferrocement reinforced with hooked fibers incorporated with 2 Layers of woven mesh as compared to that flexure strength without fibers. An increase in the flexural strength was found to be 61% and 59% for the ferrocement panels used with crimped and corrugated fibers.
4. For 30mm thick panel, increase in flexural strength was found to be 76.8% for ferrocement panels with hooked end fibers, 71.06% and 21.61% increase for flat crimped and corrugated fibers as compared to panels without fibers.
5. For 40 mm thick ferrocement panels also the flexural strength was found to be increased as compared to flat crimped and corrugated fibers panels.

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