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Behaviour of Multi Layered Fibrous Ferrocement Panels

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***Abstract*— The present study describes the performance of fibrous ferrocement panels with multilayered wire mesh and varying percentages of glass fibers. Slab panels of varying thickness are reinforced with hexagonal chicken mesh with varying number of layers of mesh. Fibrous mortar cubes with varying glass fiber percentages (0.5%,1%,1.5%,2%,2.5%, 3%, 3.5%,4%,4.5%, 5%) by weight of cement were cast and compressive test is conducted. In addition to this fibrous ferrocement panels of size (600mmx200mmx30mm) with varying glass fiber percentages, with hexagonal wire mesh of one, two and three layers were cast and flexural test is performed. It was found that when glass fibres percentage is varied, the compressive strength of fibrous mortar cubes rapidly increased upto 3% of glass fibers by weight of cement there were significant increase in flexural strength of ferrocement panels with increase in layers of wire mesh.**

Keywords*— *Fibrous Ferrocement, wire mesh, chicken mesh, glass fibers, multi layered wire mesh, Flexural strength

I. INTRODUCTION

Ferrocement is a versatile and youngest material in construction industry. Over the years it gained respect in terms of its superior performance and versatility. Whereas Fibrous Ferrocement is a type of reinforced mortar with closely spaced multiple layers of wire mesh or small diameter rods completely infiltrated with fibrous mortar. In India Fibrous Ferrocement is introduced in 90's which was used for the construction of boat hulls, separation walls in buildings and a variety of other structures like silos and bunkers etc. It is durable, versatile, cheap, durable and efficient material. The elements made of fibrous ferrocement can also be used for roofing and flooring.

II. OBJECTIVE

The main objective of this experimental work is to study the behaviour of fibrous ferrocement panels under flexural and in which hexagonal wire mesh and glass fibers were used as reinforcement. The various parameters considered in this study are as follows:

1. To study the principles of ferrocement and study the strength parameters of cementitious matrix by adding glass proportion.

2. To determine the flexural strengths of ferrocement slabs by varying the layers of mesh.

3. To compare the performance of plain ferrocement and fibrous ferrocement specimens.

III. EXPERIMENTAL WORK

Constituents of Fibrous Ferrocement: The constituents of Fibrous Ferrocement include Ordinary Portland cement, Fine Aggregate, glass fibers, Water, hexagonal wiremesh
Cement: Ordinary Portland cement confirming to IS:8112-1989 which was free from lumps and foreign matter is used with the following physical properties.

TABLE.1. TEST RESULTS ON CEMENT

Property	value
Fineness	3%
Initial setting time	50 min
Final setting time	299min
Standard Consistency	33%
Compressive Strength (28 days)	47 MPa
Specific gravity	3.05

Fine Aggregate: The Fine aggregate conforming to Zone-2 (IS:383-1970) was used. The fine aggregate used was procured from a nearby river.
Water: Potable water which is free from impurities was used in the experimental work for both mixing and curing.

Fig.1. Glass fibers

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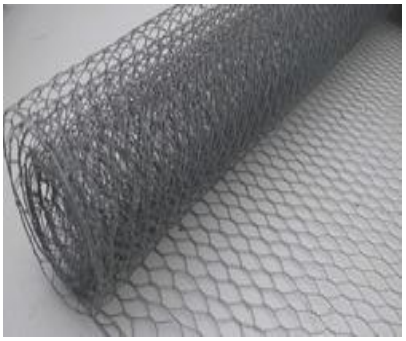

Fig.2. Hexagonal wire mesh

Glass fibers: A glass fiber when added to cementitious matrix substantially increase the static and dynamic properties and changes an inherently brittle material with low tensile strength and impact resistance into a strong composite with superior crack resistance, improved ductility & post cracking behavior.

TABLE.2. PROPERTIES OF GLASS FIBER

1	Material	Alkali Resistant Glass
2	Design	Monofilament Fiber
3	Diameter	14 microns
4	Specific Gravity	2.68
5	Colour	clear / white
6	Moisture Content	< 0.6% (ISO 3344)
7	Modulus of elasticity	72 GPa or 10,000 KSI
8	Tensile Strength	1,700 MPa

Wire mesh: Hexagonal wire mesh(Chicken mesh) was used in the experimental work with the following physical properties

TABLE-3. PROPERTIES OF HEXAGONAL WIRE MESH

1	Material	Galvanized low carbon wire
2	Mesh size(distance between faces of the hexagon)	10 mm to12mm
3	Diameter of the wire mesh	0.6 mm

Mix Proportions: Cement : Sand ratio of 1:2.5 with a W/C ratio of 0.45 was chosen and adopted along with glass fibers of 0.5% to 5% with an increment of 0.5%. by weight of cement. The dry mix is incorporated with glass fibers as shown in figure 3(a) and thoroughly mixed. Calculated amount of water is added to the dry cement fibrous mortar at particular interval while mixing shown in fig 3(b),to attain proper consistency and workable mix.

Preparation of moulds for compressive strength: To study the compressive strength, specimens of dimensions 70mmx70mmx70mm were cast with cement mortar using glass fibers ranging from 0.5% to 5% with an increment of 0.5%. For flexural tests, the specimens were cast using steel moulds in vibratory machine. The moulds were coated with oil/grease for easy demoulding. The cubes were water cured for 28 days of age. Tests for compressive strength were carried out according to IS: 516-1959. The cubes were placed in the compressive testing machine in such a manner that a load was applied to the opposite sides of cube. The load was applied without shock and was increased continuously at rate of approximately 140 kg/cm2/min until the resistance of the specimen to increasing load breaks down and no greatest load is sustained. The maximum load applied to the specimen is then recorded. The compressive strength of the specimen is calculated by dividing the maximum load applied on the specimen during the test by the cross sectional area. Mortar cubes are made adding different percentages of glass fibers and are tested in compressive testing machine. From the results the percentage of glass fiber for which highest compressive strength obtained is adopted.

TABLE.4. COMPRESSIVE TEST RESULTS OF FIBROUS MORTAR CUBES

Sl.no	Percentage of glass fibers (%)	Compressive strength after 28 days (Mpa)
1	0.5	37.67
2	1	39
3	1.5	39.31
4	2	42.68
5	2.5	47
6	3	49.34
7	3.5	46.7
8	4	40
9	4.5	38.1
10	5	36.8

From the above test results at 3% of glass fibers the mortar cubes showed a maximum compressive strength of 49.34 MPa, hence 3% of glass fibers are used by weight of cement to cast multi layered fibrous ferrocement test specimens.

Sample preparation: For flexural test, the specimens were cast using wooden moulds as shown in fig 3(c). The moulds were coated with grease and shuttering oil for easy demoulding. The required size of hexagonal mesh was first cut according to the mould sizes for flexural tests. Fibrous mortar was prepared by mixing 3 % of glass fibers by weight. During the preparation of specimen, the wire mesh is sandwiched between two layers of fibrous mortar. Similarly two and three layered fibrous ferrocement test specimens were cast. After 24 hours of casting the specimens were demoulded and transferred to curing tank. After 28 days of curing, they were taken out of water and were tested.

(a)

(b)

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(c)

Fig. 3. Casting of test specimens(a) Mixing of dry material with glass fibers (b) wet fibrous mortar after mixing with water (c) prepared fibrous ferrocement panel

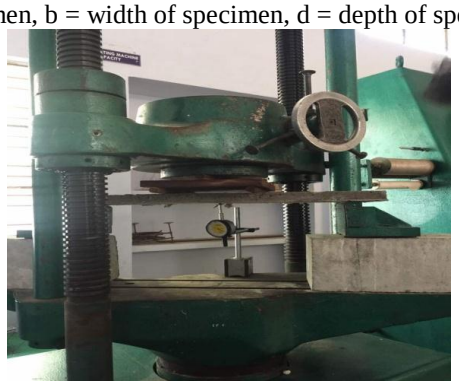
IV. TESTING

Testing of Fibrous Ferrocement panels: Flexural strength specimens were tested under two point loading over an effective span of 500mm. A detail of the test specimen set up with loaded specimen is shown in fig 4(a). the test panels were simply supported on rollers and two point loads were applied at equidistance from both the supports and in between them. Loading was applied through a hydraulic jack arrangement to cause downward deflection as shown in the fig 4(b). The load was given through the jack in small increments, to measure the deflection dial gauge is arranged. The loading was continued till the ultimate failure of the specimens is reached shown in fig 4(c).

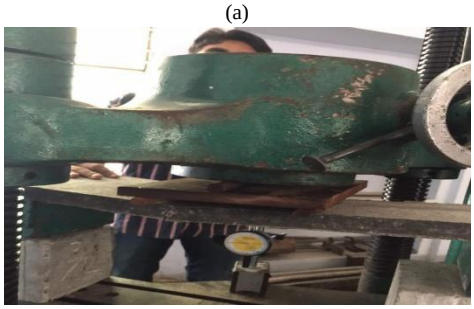
The modulus of rupture is the ultimate strength determined in a flexure test. The modulus of rupture for each sample was evaluated using the following equation.

$$R = PL/bd^2$$

Here, R= Modulus of Rupture, P = ultimate Load, L= length of specimen, b = width of specimen, d = depth of specimen.



(a)



(b)

(c)

Fig. 4 (a) 28 days cured and dried specimen arranged for flexural test (two point load) (b) Applying load in small increments (c) initial crack is observed and corresponding dial gauge reading is measured at mid span.

V. RESULTS AND DISCUSSIONS

Compressive Strength Of Cubes: Compressive strength of fibrous mortar specimens was evaluated according to IS: 516-1959 using 100T Universal Testing Machine (UTM).from the results obtained from table.3,it is clear that the compressive strength of cubes increased with the increase in percentage of glass fibers and the highest compressive strength obtained was 49 Mpa at 3% of glass fibers by weight of cement .

Flexure Test On Fibrous Ferrocement Panels :

Flexural strength of fibrous ferrocement specimens having multiple layers of wire mesh are tested on 100T Universal Testing Machine confirming to IS: 516-1959. The test results are shown in Table no.5. From the results ,it was observed that fibrous ferrocement panels having three layers of wire mesh exhibited higher flexural strength as 22.6 MPa.

TABLE.5. FLEXURAL STRENGTH TEST RESULTS OF FIBROUS FERROCEMENT PANELS

Type Of Ferrocement Panel	Flexural Strength(Mpa)
Single layered ferrocement panel without fibres	14.3
Double layered ferrocement panel without fibers	17.6
Triple layered ferrocement panel without fibres	18
Single layered ferrocement panel with 3% glass fibers	19
Double layered ferrocement panel with 3% glass fibers	20.6
Triple layered ferrocement panel with 3% glass fibers	22.6

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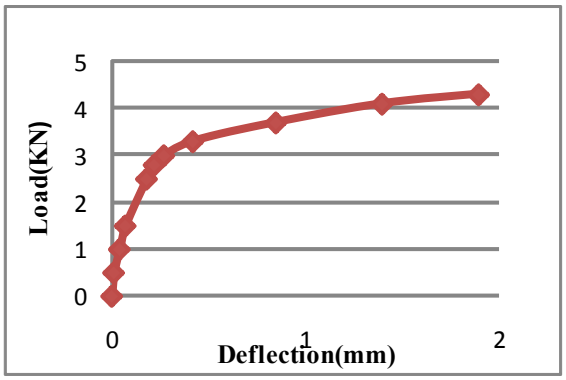
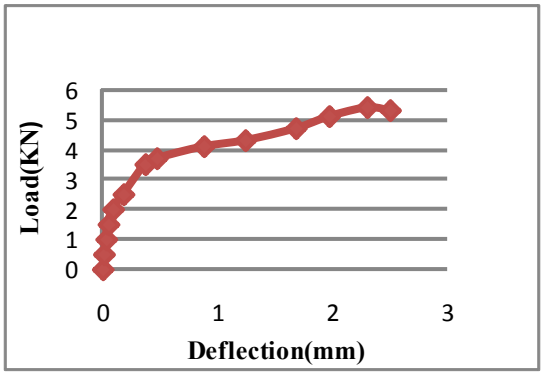
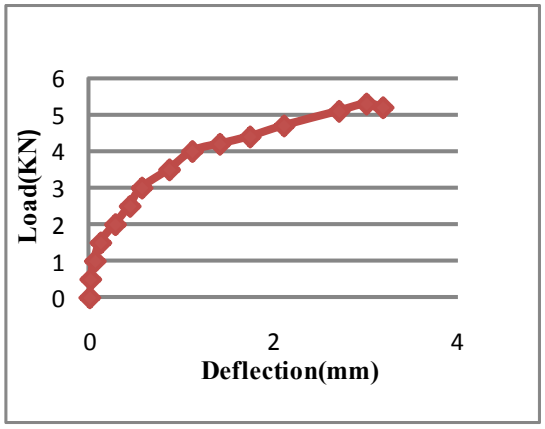


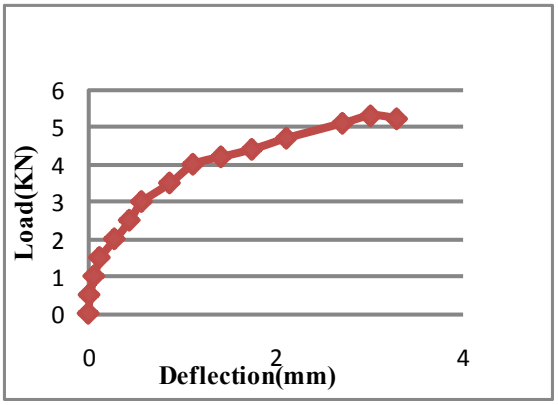
GRAPH.1: LOAD VS DEFLECTION OF SINGLE LAYERED FERROCEMENT PANEL WITHOUT FIBERS



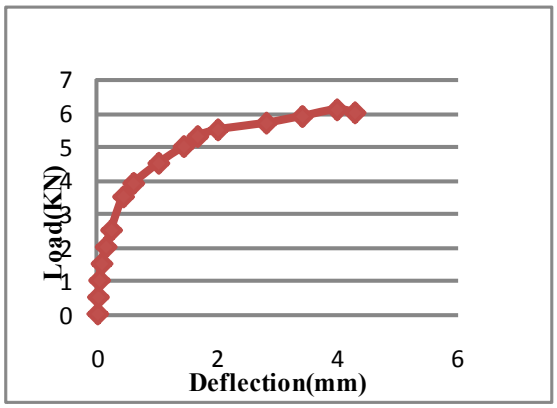
GRAPH.2: LOAD VS DEFLECTION OF DOUBLE LAYERED FERROCEMENT PANEL WITHOUT FIBERS



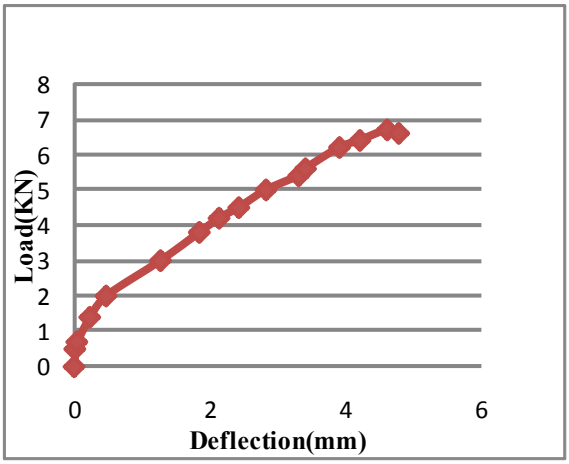
GRAPH.3: LOAD VS DEFLECTION OF TRIPLE LAYERED FERROCEMENT PANEL WITHOUT FIBERS



GRAPH.4: LOAD VS DEFLECTION OF SINGLE LAYERED FERROCEMENT WITH 3% GLASS FIBERS



GRAPH.5: LOAD VS DEFLECTION OF DOUBLE LAYERED FERROCEMENT WITH 3% GLASS FIBERS



GRAPH.6: LOAD VS DEFLECTION OF TRIPLE LAYERED FERROCEMENT WITH 3% GLASS FIBERS

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VI. CONCLUSION

Based on the experimental investigation carried out on fibrous ferrocement panels with 3% glass fibers by weight of cement. The following conclusions can be made:

- It was observed that out of all trials on glass fiber, addition of 3 % of glass fiber resulted in the maximum increase of compressive strength.
- Flexural strength values are increased for ferrocement panels with glass fibers when compared to ferrocement panels without glass fibers.
- The flexural loads at first crack and ultimate loads depend on number of reinforcing mesh layers used in ferrocement panel.
- With increase in layers of wiremesh, , the flexural strength values are considerably increased.
- Glass fibers also increases the ductility of panels and decreases the central deflection tendency as compared to others without glass fibers
- The overall results shows that the incorporation of glass fibers along with increment in number of wire mesh layers leads to increase in load carrying capacity and increase in deflection without failure.

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