International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 10, October 2017
www.ijarse.com

IJARSE
ISSN 2319 - 8354

Behaviour of Fiber Reinforced Ferrocement Beams Subjected Under Monotonic and Repeated Loading

Manoj Kumar H R[1], Chakrapani B M[2], Kishora D S[3]

[123]U G Students, Department of Civil Engineering,

Coorg Institute of Technology, Ponnampet (India)

ABSTRACT

Light weight ferrocement is a composite material consisting of cement-sand mortar (matrix) along with light weight fine aggregate (In this work foamed blast furnace slag is employed as light weight fine aggregate) as a replacement of sand in some quantity reinforced with layers of small diameter wire meshes The present work is concentrated on two major aspects, Effect of blast furnace slag on first crack and ultimate strength and Behavior of light weight ferrocement element under monotonic & repeated flexural loading. The first part of the present study has been focused on the effect of blast furnace slag (BFS) on ultimate strength with replacement of slag by 0%, 10%, 20% and 30% and second part of the work focusing the behavior of Light weight ferrocement beam under monotonic load and repeated load with increased load. The results obtained from this work is expected to be useful in determining the strength and ductility of light weight ferrocement beam subjected to similar types of forces and thus will help toward designing ferrocement elements to withstand monotonic and repeated flexural loading.

I. INTRODUCTION

Ferrocement is a combination material consisting of cement-sand matrix reinforced with layers of small diameter wire meshes. It contains of closely spaced, several layers of mesh or well rods completely surrounded in cement mortar. Usually steel bars are used in adding, to form a steel skeleton, which helps in absorbent the required shape of the Ferrocement components till the cement mortar hardens. Usually the wire mesh reinforcement will be regularly distributed across the thickness of the component. This helps in achieving improved mechanical properties viz. fracture, tensile and flexural strength, and fatigue and impact resistance. Ferrocement differs from conventional reinforced concrete primarily by the manner in which the reinforcement is arranged within the hard matrix. Since its behavior is quite differ from that of conventional re Fiber reinforced concrete (FRC) may be defined as a combination materials complete with Portland cement, aggregate, and including discrete discontinuous fibers. The character of randomly allocates discontinuous fibers is to bridge across the cracks that grow provides some post- cracking “ductility”. If the fibers are appropriately strong, sufficiently bonded to material, and permit the FRC to carry substantial stresses over a relatively great strain capacity in the post- cracking stage inforced concrete in performance, strength and potential applications, it is classed as a discrete material.

1.1 Objective of Present work

The following studies are done in this Project work.

1. Basic material testing i.e. Cement, sand, Fiber and wiremesh.
2. Behavior of Fiber reinforced ferrocement beams under Monotonic and Repeated flexural loading.
3. Study the behaviour of the ferrocement and fiber reinforced beam subjected to flexural monotonic loading at first crack and ultimate loading.

This Study tries to provide information on the "Behaviour of Fiber reinforced ferrocement beams under Monotonic and Repeated flexural loading". The results obtained from this work is expected to be useful in determining the strength and ductility of Fiber reinforced Member subjected to similar types of forces and thus will help toward designing fiber reinforced beams to withstand Under flexure loading.

Study focus to predict experimental work on Fiber reinforced beams under Flexure loading.

II. LITERATURE REVIEW

2.1 General

This chapter deals with some of the investigation in the field of ferrocement beams subjected to flexure and shear, both experimental and theoretical works

2.2 Flexural Behaviour Of Ferrocement Beams In Long Term Loading By T.Onet And C.Magureanu

Observing the research done by T.Onet and C.Magureanu following conclusions were obtained.

2.2.1 Conclusions

1. Ferrocement is generally a flexible material and a very flexible one if the sections are under reinforced. The value of long term deformation factor (□ cs) established by means of strains or deflections indicates that the long-term deflection influence the behaviour of beams much more than the instantaneous one.

The mentioned difference in behaviour can be explained by the following:

a. There is a lack of reinforcing steel in the elements which is responsible for the observed large deformations, deflections, and sectional curvatures under long-term loading.

b. The beams reinforced with woven hexagonal wire meshes while the plates were reinforced with welded square meshes which are less deformable than the former loads.

c. The ferrocement beams were reinforced in central area between forces in the tension side. The effect of compressive reinforcement on long term

2. Ferrocement being a flexible material, the member must be designed considering deflections as in ACI guide for the design, construction and repair of ferrocement. To ensure the rigidity of the element it is really necessary to consider first deformability of the ferrocement members than the proper selection of cross sectional shape.

3. The marked evolution in the time of crack width which was noticed in the experiments is due to the reduced quantity of reinforcement. There is insufficient steel to resist the tensile force carried by the uncracked concrete once a crack occurs without developing crack widths which exceed the serviceability requirements of ferrocement. It is true that excessive cracking of ferrocement beams must be correlated with deformability of the member. Limiting deformability by, for instance, increasing tensile and compressive reinforcement has also beneficial effects on ferrocement members cracking state.

2.3 Cracking Behaviour And Ultimate Strength Of Ferrocement In Flexure By M.A.Mansur And P.Paramasivam

By observing the research done by M.A Mansur and P.Paramasivam, following conclusions were obtained.

The following conclusions can be drawn from the analytical and experimental investigation reported in this paper

2.3.2 Conclusion

1. Both first crack and ultimate moment increases with increasing matrix grade (decreasing W/c ratio) and increasing volume fraction of reinforcement.

2. Lower matrix grade is more favourable with respect to cracking, i.e. larger number of cracks appears with smaller maximum and average crack width.

3 .Higher volume fraction of reinforcement provides higher effective control of crack width

III. MATERIALS USED AND ITS PROPERTIES

3.1. Cement: Portland Pozzolana cement conforming to IS: 8112-1989 [78], which was stored in a cool and dry place, was used. The physical properties of cement are as shown in table-3.1

Tests on cement

The various test carried out on cement are:

1) Normal consistency test.

2) Setting time test.

3) Fineness of cement by 90 microns sieve.

4) Specific gravity of cement.

Standard consistency(%)	33
Initial setting time(min)	40
Final setting time(min)	434
Finesss of cement	1.95
Specific gravity of cement	3.15

IJARSE
ISSN 2319 - 8354

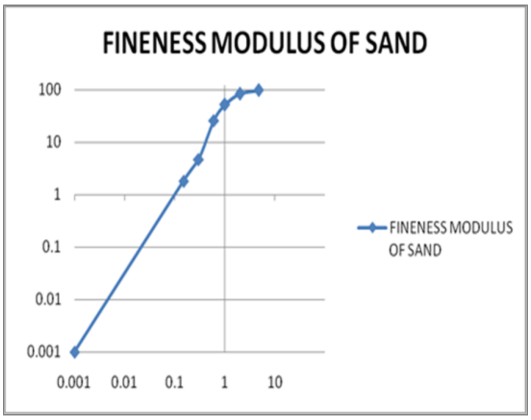
Table-3.1 Properties of Cement

3.2 Sand: Fine aggregate used in the Fiber reinforced ferrocement is taken from NARSIPURA river bed near KUDALA SANGAMA. This river sand is totally free from all impurity and organic matters. It is conformed from IS: 383

Tests on fine aggregates

Various tests conducted on fine aggregate are

1) Specific gravity of fine aggregate.
2) Sieve analysis.



Sieve Sizes in Mm

3.3 Water: Ordinary potable water was used for mixing. Water is an important ingredient in mortar as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality is required to be looked into very carefully. The mixing water should be fresh, clean, and potable. The water should be relatively free from organic matter, silt, oil, sugar, chloride, and acidic material. It should have $P_H \geq 7$ to minimize the pH of the mortar slurry. Salt water is not acceptable, but chlorinated drinking water can be used.

Table-3.3 Properties of Sand

Fineness modulus	4.33
Density (kN/m^3)	1.32
Water content (%)	0.5
Specific gravity	2.42

IJARSE
ISSN 2319 - 8354

3.4 Fiber

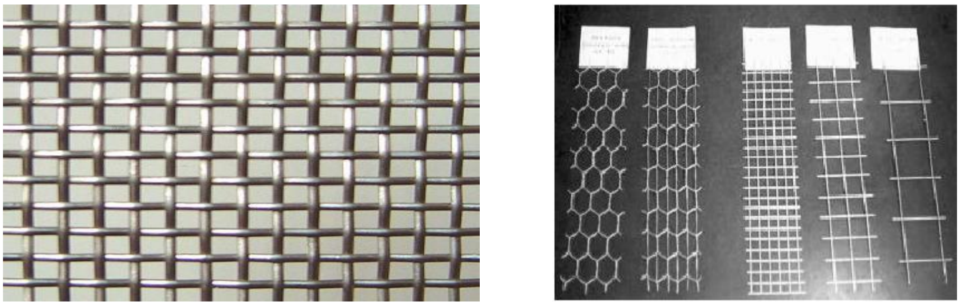
The fibers help to transfer load to the internal micro cracks. FRC is cement based composite material that has been developed in recent years. It has been successfully used in construction with its excellent flexural-tensile strength, resistance to spitting, impact resistance and excellent permeability and frost resistance. It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar. These fibers have many benefits. Steel fibers can improve the structural strength to reduce in the heavy steel reinforcement requirement. Freeze thaw resistance of the concrete is improved. Durability of the concrete is improved to reduce in the crack widths. Polypropylene and Nylon fibers are used to improve the impact resistance. Many developments have been made in the fiber reinforced concrete.

Steel Fiber

Steel-fiber volumes used in concrete typically range from 0.25% to 2%. Volumes of more than 2% generally reduce workability and fiber dispersion and require special mix design or concrete placement techniques. Steel fibers do not affect free shrinkage. Steel fibers delay the fracture of restrained concrete during shrinkage and they improve stress relaxation by creep mechanisms

Hooked end Steel Fiber

3.5 Wire mesh: Common wire meshes have hexagonal or square openings. Meshes with hexagonal openings are sometimes referred to as chicken wire mesh or aviary mesh. They are not structurally as efficient as meshes with square openings because the wires are not always oriented in the directions of the principal (maximum) stresses. However, they are very flexible and can be used in doubly curved elements. Meshes with square openings are available in welded or woven form. Welded-wire mesh is made out of straight wires in both the longitudinal and transverse directions. Thus welded-mesh thickness is equal to two wire diameters. Woven mesh is made of longitudinal wires woven around straight transverse wires.



Types of wiremesh

3.6 Parameters considered

Two parameters have been considered in studying the workability of ferrocement mortar, viz., water-cement ratio (w/c) and percentage of Fiber

Water-cement ratio:

i) The value of water-cement ratio is 0.45, by weight of cement has been used.

ii) Percentage of Fiber Used : A mix proportion of cement to fine aggregate of 1:2 is used in this investigation. Four percentages of Fibers are examined, viz., 0%, 0.5%, 1% and 1.5% by weight.

3.7 Mix Proportioning

The ranges of mix proportions recommended for common ferrocement applications are Sand-cement ratio by weight, 1.5 to 3.Water-cement ratio by weight, 0.35 to 0.5.The higher the sand content, the higher the required water content to maintain the same workability. Fineness modulus of the sand, water-cement ratio, and sand-cement ratio should be determined from trial batches to insure a mix that can infiltrate (encapsulate) the mesh and develop a strong and dense matrix. Shrinkage is not a problem in ferrocement because of the high reinforcement content. Instead, in ferrocement mortars it is most important to maintain plasticity as a design criterion.

The moisture content of the aggregate should be considered in the calculation of required water. Quantities of materials should preferably be determined by weight. The mix should be as stiff as possible, provided it does not prevent full penetration of the mesh. Normally the slump of fresh mortar should not exceed 2 inch. (50mm). for most applications, the 28-day compressive strength of 3 by 6-m. (75 by 150-mm) moist-cured cylinders should not be less than 5000 psi (35 MPa**).**

3.8 Mixing procedure:

The following procedure was followed in mixing operation:

1. Sand and steel fibers were mixed thoroughly along with the cement.

After thorough mixing of dry material, The required water was added to the mix and manual mixing was continued until homogeneous mixture was achieved.

IV CASTING AND TESTING OF SPECIMEN

4.1 Casting and Curing

A total of 54 Ferrocement specimens have been cast on edge in 9 groups. 6 specimens were cast at a time, using of teak wood moulds as shown in Fig 4.1. The layer of mesh was held in position at required spacing in the moulds by means of suitable aluminum spacers, which were removed while casting. A plate vibrator was used for compacting the specimens. Moulds were dismantled 24 hours after casting and cured under water up to age of 28 days. After curing the specimens were removed from water and kept in a cool and dry place till they were tested. All the specimens were white washed before applying the load to notice the cracks clearly.

Casting mould

4.2 Instrumentation

Deflections and strains on mortar surfaces at various levels across the depth of the specimens in pure flexure zone were recorded during testing of ferrocement elements under monotonic and repeated flexural loading.

Deflections were measured at mid points and locations of these points are shown in figure 4.2. For measuring deflections at these points, dial gauges of 25mm range with least count of 0.01mm were used. During testing, these dial gauges were reset when the deflection exceeded the range of gauges.Strains on mortar surface of specimens were measured by demec (de mountable mechanical) gauge over demec points fixed to the mortar surface with an adhesive. Surface strains were measured on top and bottom edges of the specimens and at other levels of specimen across the depth. strains were measured on both the faces of specimen over gauge length of 200mm and least count of demec gauge was 0.79*10^-5.

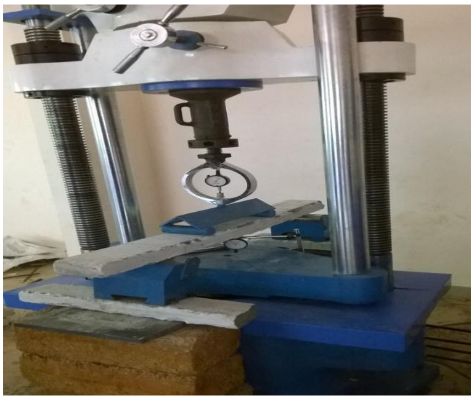
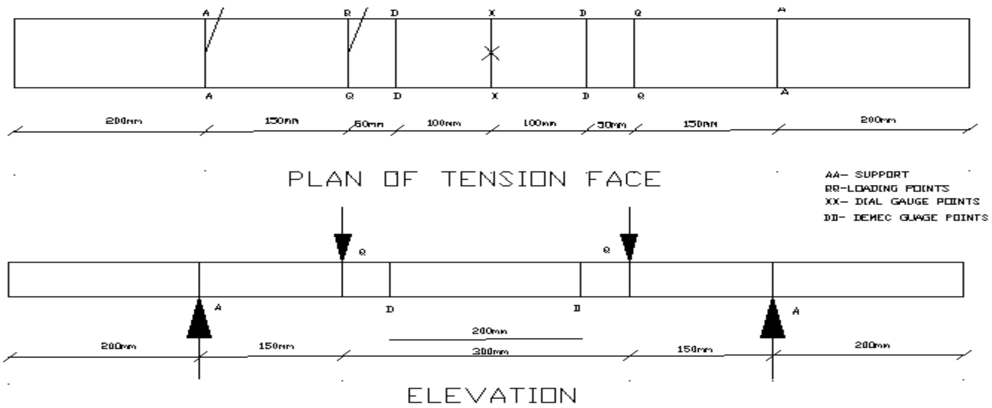


Fig.4.1(a) Demec gauge

4.3 Testing of Specimens

In each set three specimens were cast and they were tested under monotonic loading. A UTM is used for testing specimens under monotonic loading as shown in figure 4.2. Two point loading was applied at one fourth span points, ie at 150mm from supports using a mechanical screw jack of 100kN capacity through a distribution steel high beam. Applied load was measured using a proving ring of 100kN capacity.

IJARSE
ISSN 2319 - 8354



Details of Demec & Dial Gauge Points specimens

4.4 Determination of first crack strength

Moment at first crack (Mcr) for all the specimens tested under monotonic loading has been given in column 6 of table 5.1. Modulus of rapture at first crack, fcr is calculated based on the gross section as

$$fcr = \frac{Mcr\, y}{Ig}$$

Where,

fcr = Is the crack strength

Mcr = Is the crack in moment

y = is the depth of neutral axis (25 mm for the specimen tested)

Ig = Is the gross moment of inertia

To study the effect of percentage of mesh wires in the longitudinal direction(pm) on data of plain specimen and specimens reinforced with only wire meshes under monotonic load have been used in plotting the relationship between $\frac{fcr}{\sqrt{fcu}}$ and pm. To study the effect of position of skeletal steel bars on data of plain specimens and of specimens reinforced with bars at centre and meshes on either side under monotonic and repeated load have been used in plotting the relationship between $\frac{fcr}{\sqrt{fcu}}$ and pm. For the specimens with distributed meshes and steel bars and tension face, the first crack strength was observed to the almost equal to the first crack strength of identical specimens without steel bars. Hence the equations obtained for specimens with distributed meshes only have been used for specimens with steel bars on tension face. For the range of parameters used in this study and probably due to limited test data, any trend of variations fcr in with pm has not been noticed. It is also possible that the first crack forms on the mortar cover over the mesh and hence probably fcr depends more on the property of mortar than of meshes which are inside the specimens. Hence a horizontal line represent the mean

IJARSE
ISSN 2319 - 8354

values of $\frac{fcr}{\sqrt{fcu}}$. Equations for computation of first crack strength fcr for different reinforcement and loading conditions obtained from this figures are given in table 5.1.

4.5 Determination of modulus of rupture at Ultimate

Using the test data, extreme fiber stress at ultimate has been calculated from the simple bending theory as

Where

$$fu = \frac{6Mu}{bh^2}$$

fu = modulus of rupture in flexure (Mpa)

Mu = ultimate bending moment (N mm)

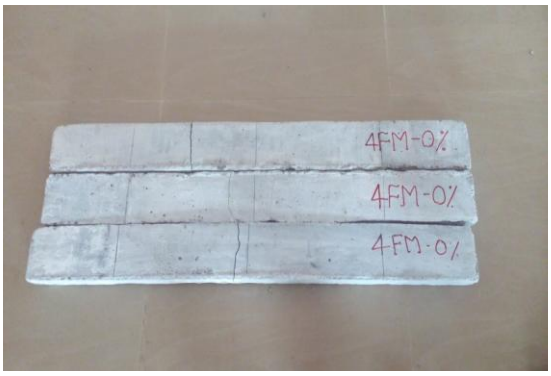
b = breadth of beam (mm)

h = overall depth of the specimen (mm**)**

Values of Mu for all the specimens tested under monotonic loading has been given in column 4 of table 5.1

4.6 Picture of Experimented SpecimensvFailure pattern of Beams

0% Monotonic cement mortar



4 Layers Meshes with 0% Fiber

4 Layers Meshes with 0.5% Fiber

4 Layers Meshes with 1% Fiber

IJARSE
ISSN 2319 - 8354

4 Layers Meshes with 1.5% Fiber

4 Layers Meshes with 0% Fiber

4 Layers Meshes with 0.5% Fiber

4 Layers Meshes with 1% Fiber

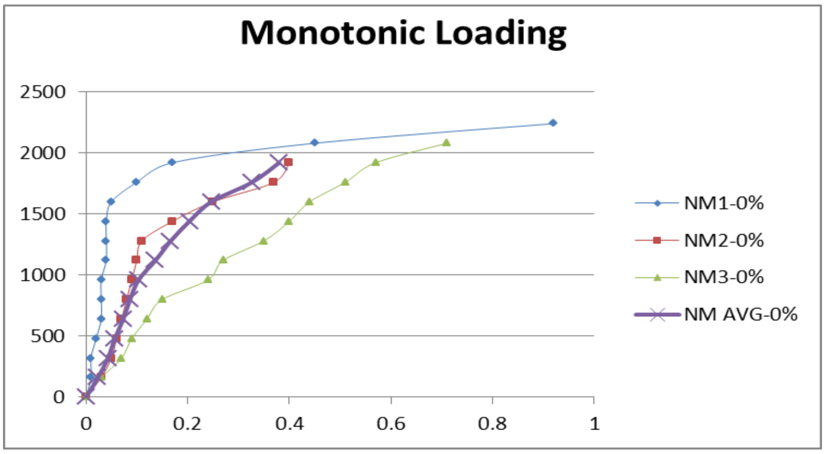
4 Layers Meshes with 1.5% Fiber

V. RESULT AND DISCUSSION

5.1 Graphical Representation

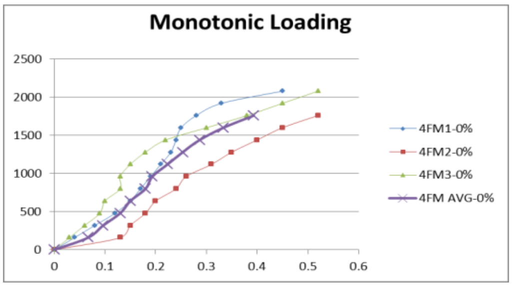
Monotonic Load

Load V/S Deflection Curves

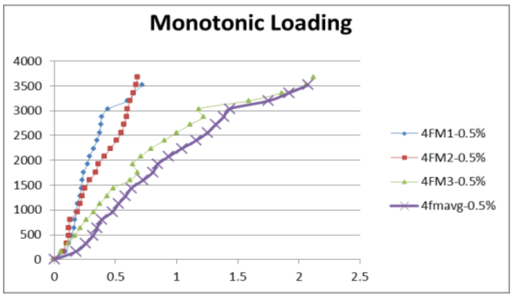


0% Monotonic cement mortar

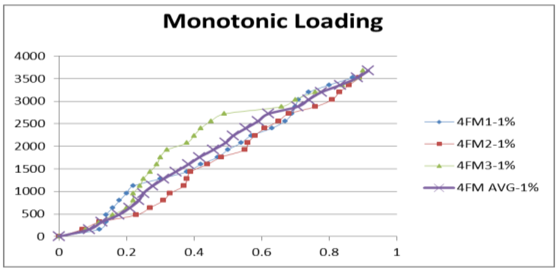
International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 10, October 2017
www.ijarse.com
IJARSE
ISSN 2319 - 8354



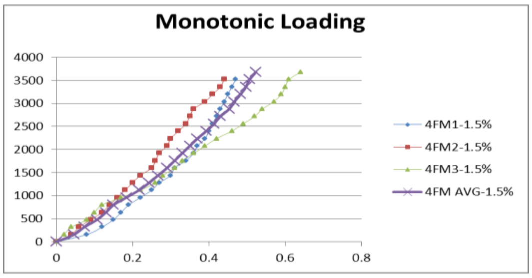
4 Layers Meshes with 0% Fiber



4 Layers Meshes with 0.5% Fiber



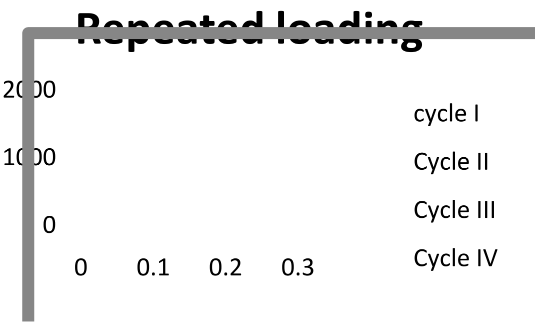
4 Layers Meshes with 1% Fiber



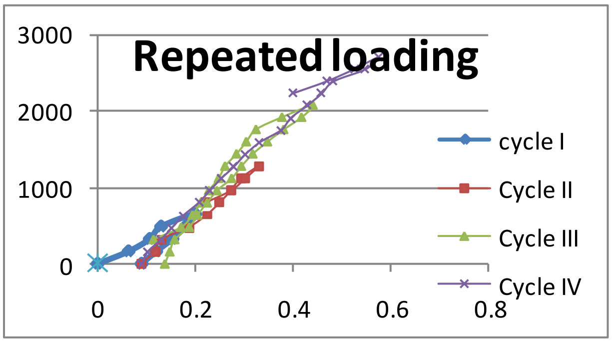
4 Layers Meshes with 1.5% Fiber

Repeated Load

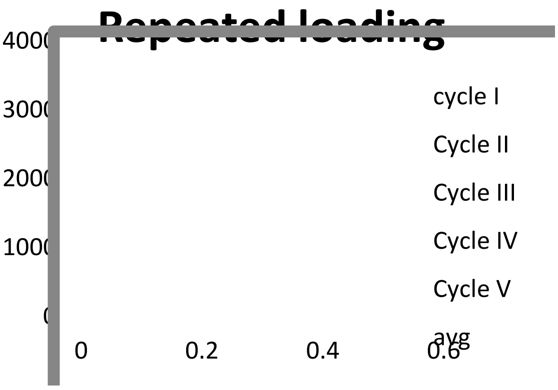
Load V/S Deflection Curves



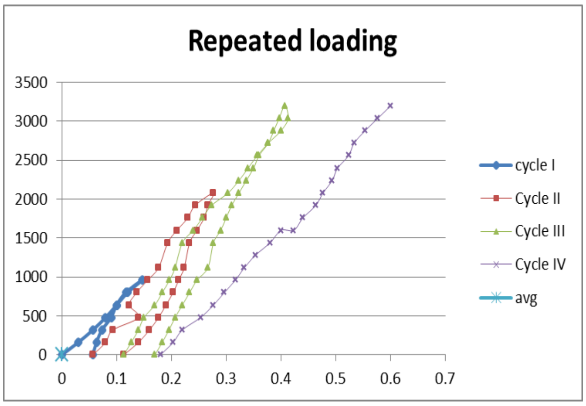
4 Layers Meshes with 0% Fiber



4 Layers Meshes with 0.5% Fiber



4 Layers Meshes with 1% Fiber



4 Layers Meshes with 1.5% Fiber

5.2.First crack strength of specimens under monotonic and Repeated loading

	Specimen	No of layers	Ultimate load (N)	Cube strength f_{cu} (Mpa)	Cracking moment M_c (N-m)	Experiment cracking strength f^e_{cr} (Mpa)	f^e_{cr} sqrt f_{cu}
A	NM-0%	0	2079.87	42.2	155.990	7.57	1.16
B	4FM-0%	4	1973.21	42.2	147.99	7.03	1.08
	4FM-0.5%	4	3946.42	44.6	295.981	14.73	2.20
	4FM-1%	4	4053.08	53.1	303.981	15.10	2.07
	4FM-1.5%	4	4639.71	49.1	347.978	17.2	2.45
C	4FR-0%	4	1119.93	42.2	83.994	4.1	0.63
	4FR-0.5%	4	3199.8	44.6	239.985	12	1.79
	4FR-1%	4	4319.73	53.1	323.979	16.1	2.20
	4FR-1.5%	4	3359.79	49.1	251.984	12.3	1.75

5.3.Variation of Experimental First crack strength

Mesh layers	First crack strength equation
0	$f^e_{cr} = 1.16(f_{cu})$^0.5
4	$f^e_{cr} = 1.95(f_{cu})$^0.5
4	$f^e_{cr} = 1.59(f_{cu})$^0.5

VI.CONCLUSION

The following conclusions can be drawn from experimental investigation.

1. Both first crack and ultimate moment increases with increasing volume fraction of reinforcement.
2. Higher volume fraction of reinforcement provides higher effective control of crack width.
3. The experimental investigation presented here to predictions of the ultimate moment capacity of Fiber Reinforced Ferrocement.
4. Wire meshes are more effective in increasing the first crack strength of Fiber Reinforced Ferrocement.

5. The ultimate crack strength in flexure increases for 1.5% of Fiber added and greater volume fraction of wire meshes used.

6 .Fiber Reinforced Ferrocement beams have good moment of resistance.

7. The number of repetitions are more when fraction of steel increases.

REFERENCE

[1.] ACI COMMITTEE, 549, "Guide for the Design, Construction and Repair of Ferrocement", American Concrete Institute Structural Journal, Vol.85, No.3, May-June 1988, pp 325-351.

[2.] DESAYI. P. and JOSHI. A. D. "Ferrocement Load-bearing wall elements", Journal of the Structural Division, Proceedings of the American Society of Civil Engineers, Vol.102, No.ST9, September 1976 pp 1903-1916.

[3.] WALKUS .B.R. "Testing and Test methods for Ferrocement" Journal of Ferrocement, Vol. 16, No. 1, January 1986, pp 27-37.

[4.] WINOKUR A. and ROSENTHAL, L. "Ferrocement in centrally loaded compression elements", Journal of Ferrocement, Vol. 12, No. 4, October 1982, pp 357-364.

[5.] SURESH G.S. "Studies on Ferrocement under monotonic, cyclic and repeated loading", Ph.D thesis, Indian Institute of Science, Bangalore, August 1995

s