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Experimental Investigation of Moment Curvature Characteristics of Ferrrocement Hollow Slab

Raj kishor sah[1], M. Pradeep kumar[2]
(*Department of Civil Engineering, PSNA College of Engineering and Technology,Kothandaraman Nagar, Dindigul -624 622, Tamilnadu, India)*

Abstract: *It is evident from literature review that in the recent decades the thrust for finding an alternative to the costly construction material is increasing several alternative have been tested across the globe.Some viable alternative are found,also many techniques of replacing the cement and addition of ferrocement is studied. The methods which are found to be cost effective and feasible are also tried in construction in various areas. Once such alternative technique is providing subsidiary cement in the way of addition of ferrocement in hollow slab. In this paper, the general behaviour of Fiber Reinforced Ferrocement composite and the studies carried out by various investigators on mechanical properties are summarized and presented. In this experiment moment-curvature behaviour,Ductility,Stiffness degradation,Ultimate load carrying capacity and Energy absorption were determined. The comparision is of load carrying capacity, stiffness degradation, Ductility and Energy absorption of fiber reinforced Ferrocement Hollow Slab with the same slab without fiber. This paper details the attempt made to check moment-curvature characteristics of ferrocement hollow slab.*
Keywords*: HFFC,FRC,Ferrocement,Ductility,Stiffness degradation*

I. Introduction

Slabs are the most widely used structural elements of modern structural complex and the reinforced concrete slab is the most useful discovery for supporting lateral loads in buildings. In addition to the supporting lateral loads, slabs act as deep horizontal girders to resist wind and earthquake forces that act on a multistoried frame. Their action as girder diaphragms of great stiffness is important in restricting the lateral deformations of a multistoried frame.

The cast in – situ reinforced concrete roof floor slab is the simplest form of slab construction, but it is rather wasteful in materials particularly cement. Substantial savings can be effected by modifying the composition of the slab so that its weight is reduced without imparing its strength or behaviour. For that we go for ferrocement slabs. Ferrocement is a composite material which is made up of cement mortar reinforced with steel fibers in the form of wire mesh, in which the brittle cement mortar matrix is reinforced with layers of ductile wire meshes dispersed throughout, thus resulting in a material of better structural performance.

While the mortar provides the mass, the steel fiber imparts tensile strength and deformability to the material. Ferrocement is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small size wire mesh. In its role as a thin reinforced concrete product and as laminated cement – based composite, ferrocement has found itself in numerous applications both in new structures and repair and rehabilitation of existing structures. Compared with the conventional reinforced concrete, ferrocement is reinforced in two directions; therefore, it has homogenous – isotropic properties in two directions. Benefiting from its usually high reinforcement ratio, ferrocement generally has a high tensile strength and a high modulus of rupture. In addition, because the specific surface of reinforcement of ferrocement is one to two orders of magnitude higher then that of reinforced concrete, larger bond forces develop with matrix resulting in average crack spacing and width more than one order of magnitude smaller than in conventional reinforcement concrete. Other appealing features of ferrocement include ease of prefabrication and low cost in maintenance and repair. Based on the aforementioned advantages, the typical applications of ferrocement include water tanks, boats, housing wall panel, roof, formwork and sunscreen.

As a laminated composite, ferrocement often suffers from severe spalling of matrix cover and delamination of extreme tensile layer at high reinforcement ratio, resulting in premature failure. Therefore, serviceability consideration rather than strength limit would dominate composite design. Adding discontinuous short fiber to cementitious matrix, which could bring significant improvement in ductility and shear capacity as well as moderate increase in tensile strength, turns out to be a logical solution to solve or alleviate these problems. Also for a good earthquake resistant design is to have sufficient ductile materials at points of tensile stresses.

II. Scope And Objective

So far moment – curvature relationship for reinforced concrete slabs, beams and ferrocement beams has been developed. In this thesis, moment – curvature behaviour, Ductility, Stiffness degradation, Ultimate load carrying capacity and Energy absorption were determined. These parameters have an important role to play in predicting the behaviour of ferrocement members under flexure. The main objective of this thesis is

- ❖ To determine the Moment – Curvature Characteristics of the Fiber Reinforced Ferrocement Hollow Slab under cyclic loading.
- ❖ To compare the parameters of load carrying capacity, stiffness degradation, Ductility and Energy absorption of fiber reinforced Ferrocement Hollow Slab with the same slab without fiber.

III. Literature Review

3.1 General

In this chapter, the general behaviour of Fiber Reinforced Ferrocement composite and the studies carried out by various investigators on mechanical properties are summarized and presented.

3.1.1 Review of Literature

1. **K.Ramesh, D.R.Seshu,** have derived the characteristic equation of the stress – strain curve for Hybrid Ferro Fiber Concrete which was used to study the moment – curvature characteristics of HFFC sections. The theoretical procedure has been validated by conducting an experimental investigation on 23 reinforced concrete beams provided with HFFC at critical sections. The correlation between experimental and analytical values of ultimate moments and corresponding curvatures arrived at based on the above procedure is found to be good. The moment – curvature diagram of HFFC sections can be idealized as a bi – linear form.
2. **P.J. Walker** summarizes the experimental and theoretical work undertaken to study the behaviour of ferrocement elements in flexure. Results of six beam test are presented. The influences of both mesh content and cement mortar properties on beam behavior are considered. Measurements ndicated that increased mesh content and mortar strength enhanced both the ultimate moment capacity and stiffness of the beams.
3. **M.S.Mathews, J.Sudhakumar and PJayasree** have investigated the durability aspects of ferrocement in marine environment by conducting laboratory accelerated tests and field tests. The results have indicated that the ferrocement specimens subjected to accelerated tests and those in the splash zone of field tests suffered appreciable loss of strength. The specimens in the atmospheric and immersion zone showed improvements in the ultimate tensile strength during the test.

IV. Specimen Details

Two slab panels of size 3000 mm in length and 140 mm in depth with the breadth of 770 mm in the bottom and 690 mm in the top were cast. The details of the specimen are mentioned in table 3.2

Main Rods	8mm Φ @ 130mm spacing
Distributor Rods	4mm Φ @ 150mm spacing
Shear Connectors	4mm Φ @ 150mm spacing
Chicken Mesh	3layers in both flanges
Clear Cover	5mm

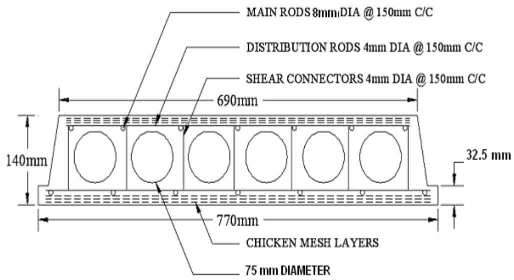


fig : cross section of the specimen

RECRON

CASTING

EXPERIMENTAL SETUP

FINISHED SLAB

V. Test Procedure

To determine the Moment – Curvature characteristics and the Ultimate load carrying capacity of the Fiber Reinforced Ferrocement Hollow Slab, a total number of four slabs were cast. The effective span of the slab was 2800mm. The Fiber Reinforced Ferrocement Hollow Slab was tested in a 25 tones Self Straining loading frame with 500kN capacity proving ring. The specimen is placed on the Self Straining load frame with its one end hinged and other end as roller. The load applied to the slab was cyclic loading with an increment of 5kN load in each cycle by means of hydraulic jack. The load was applied till the slab reaches its ultimate load. The top and bottom strains of the Fiber Reinforced Ferrocement Hollow Slab are measured by means of curvature meter. The crack patterns are also observed.

The history of the load sequence followed for the test is presented in graph 3.1. Totally 11 cycles were imposed.

Test result of component specimen

With recron 3s fiber

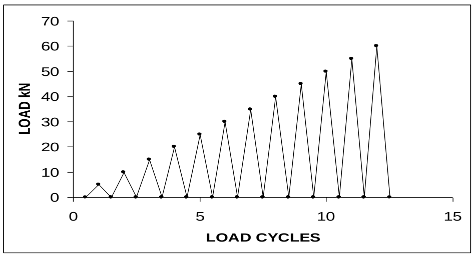
Compressive strength of cube – 37.63 Mpa

Compressive strength of cylinder – 32.45 Mpa

Without recron 3s fiber

Compressive strength of cube – 31 Mpa

Compressive strength of cylinder – 30.56 Mpa



GRAPH LOAD SEQUENCE DIAGRAM

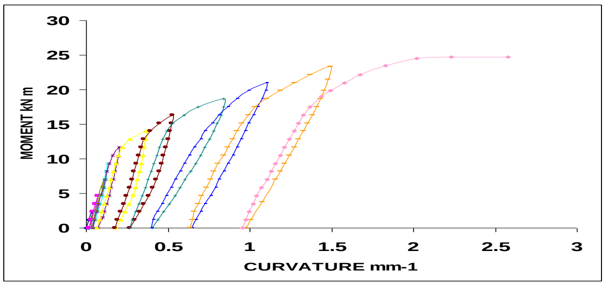
FIG.CURVATURE METER

FIG CRACK PATTERN

Behaviour of Ferrocement Hollow Slab without Fiber

Table 5.1 Experimental results of the slab without Recron fiber

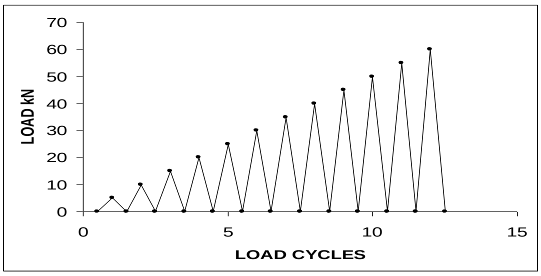
Load cycle No.	Moment kN m	Curvature mm^{-1} x 10^{-2}	Ductility factor		Stiffness degradation kN m^2	Energy absorption kN	
			Relative	Cumulative		Relative	Cumulative
1	2.3	.035	0.0959	0.0959	16.67	0.268	0.268
2	4.7	0.07	0.1808	0.2767	12	0.6062	0.8742
3	7	0.105	0.271	0.5477	8.8	0.775	1.649
4	9.3	0.126	0.328	0.8757	8.3	1.175	2.824
5	11.7	0.202	0.523	1.3987	6.67	5.625	8.449
6	14	0.337	1.027	2.426	5	20.125	28.574
7	16.3	0.53	1.452	3.878	4.5	21.125	28.574
8	18.7	0.837	2.293	6.171	3	39.125	88.824
9	21	1.102	3.019	9.190	2.5	53.375	142.199
10	23.3	1.492	4.087	13.277	2.4	81.75	223.949
11	24.7	2.58	6.712	19.989	2.1	196.37	420.319



GRAPH 5.1.1.a MOMENT Vs CURVATURE

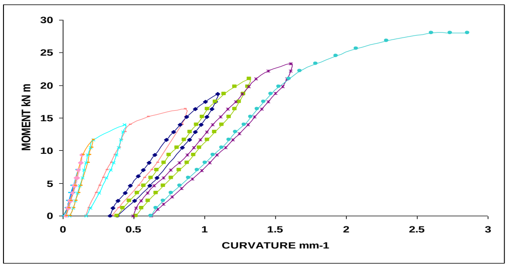
Behaviour Of Fiber Reinforced Ferrocement Hollow Slab

Load cycle No.	Moment kN m	Curvature mm^{-1} x 10^{-2}	Ductility factor		Stiffness degradation kN m^2	Energy absorption kN	
			Relative	Cumulative		Relative	Cumulative
1	2.3	0.043	0.1102	0.1102	19	0.1156	0.1156
2	4.7	0.071	0.182	0.292	15	0.1937	0.3093
3	7	0.107	0.274	0.5662	13	0.925	1.234
4	9.3	0.133	0.331	0.8972	11.25	2.75	3.984
5	11.7	0.21	0.5487	1.4459	10	4.85	8.834
6	14	0.436	1.1179	2.5638	10	22.125	30.959
7	16.3	0.857	2.197	4.7608	7	46.37	77.33
8	18.7	1.093	2.795	7.556	5.2	26	103.33
9	21	1.314	3.369	10.925	3.6	21	124.33
10	23.3	1.607	4.1205	15.0453	3	44.25	168.58
11	28	2.857	7.371	22.416	2.67	347	519.58



Graph 5.1.1.b Load Sequence Diagram

.Table Experimental results of the slab with Recron fiber



GRAPH5.1.2 MOMENTVsCURVATURE

VI. Conclusion

- The first crack load has been observed that the fiber reinforced ferrocement hollow slab was more than that of ferrocement hollow slab without fiber.
- The ultimate moment carrying capacity is marginally increased for the fiber reinforced ferrocement hollow slab than the ferrocement hollow slab without fiber.
- In general there is stiffness degradation for both the slabs.
- Initial stiffness of the ferrocement hollow slab without fiber is lower than that of the fiber reinforced ferrocement hollow slab.
- The cumulative curvature ductility for fiber reinforced ferrocement hollow slab is 1.121 times more than that of ferrocement hollow slab without fiber.
- The Energy absorption for the fiber reinforced ferrocement hollow slab is 1.24 times greater than that of the ferrocement hollow slab without fiber.
- By the inclusion of the fiber, the failure pattern of the slab is changing considerably i.e.,
- The crack width is reduced in case of fiber reinforced ferrocement hollow slab.
- The ductility and energy absorption is relatively increased in the fiber reinforced ferrocement hollow slab.
- Since the fiber reinforced ferrocement hollow slabs have high ductility they have the ability to resist earthquake and they can be used for buildings constructed in the earthquake zone.

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