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FLEXURAL BEHAVIOUR OF FERROCEMENT COMPOSITE SLAB

S.Dharanidharan *
Assistant Professor, Department of Civil Engineering, Sri Shanmugha College of Engineering and Technology, India

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ABSTRACT

This project deals with an investigational program to understood the flexural behavior of a Ferro cement composite slabs under mid third loading. The concept of composite slabs bring in shut decking or shear connectors are well established. But still, in countries like India, the application of same is limited due to difficulties in manufacture and also due to concerns like fire resistance, durability, aesthetics etc., this study is an attempt to exploit the concept of steel – concrete composite to a comparable system in which steel sheeting is replaced by Ferro cement elements. These elements will act as permanent form work and also participating in the structural performance of the slab. The combination of Ferro cement slab with concrete slab, when the two are so connected that they act as a single unit in resisting flexure is called as composite slab.

KEYWORDS: Ferro cement, fire resistance, durability, aesthetics.

INTRODUCTION

A large number of civil structures everywhere the world are in a state of thoughtful deterioration today due to carbonation, chloride attack, etc. Moreover numerous civil constructions are no longer considered safe due to increase load specifications in the design codes or due to overloading or due to under design of existing structures or due to lack of quality control. 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. These leads to the development of Ferro cement structures. Ferro cement is a type of thin-wall reinforcement concrete commonly constructed of hydraulic cement mortar, reinforced with closely spaced layers of continuous and relatively small diameter mesh. The strength properties of the material are to be determined by testing a significant number of samples. Ferro cement is considered to be an extension of reinforced concrete technology. Ferro cement possesses a degree of toughness, ductility, strength and crack resistance that it is considerably greater than that found in other forms of concrete construction. These properties are achieved in structures with a thickness that is generally less than 25mm, a dimension that is nearly unthinkable in other forms of concrete construction, and a clear improvement over Conventional reinforced concrete. Surprisingly, good performance can be achieved in Ferro cement with almost primitive field conditions and it does not necessarily require highly skilled practitioners. One can call it a high technology material, yet its production in terms of required labours skills and lack of sophistication of its constituent parts could be viewed as a low technology. In 1940 Pier Luigi Nervy, an Italian engineer, designer and contractor, used Ferro cement first for the construction of aircraft hangars, boats and buildings and a variety of other structures. It is a very durable, cheap and versatile material.

INGREDIENTS USED IN FERRO CEMENT SLAB

For developing rich mix, it is important to select proper ingredients, evaluate their properties and understand the interaction among different materials for optimum usage. The materials used for this investigation were the same as that used for the normal cement mortar mix such as cement, fine aggregate (FA) and water. The performance requirements of cement mortar may involve the following properties.

- Long term mechanical and durability properties,
- Early strength,
- Toughness,
- Volume stability,

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- Longer service life.

In order to achieve good quality, optimum proportions must be selected considering the characteristics of cementitious materials, aggregate quality, paste proportion, aggregate paste interaction, admixture type, dosage and meticulous care in mixing and handling.

Cement

Cement is the most important ingredient used. One of the important criteria for the selection of cement is its ability to produce improved microstructure. The cement should be fresh of uniform consistency and free of swellings and external matter and of the nature or grade depending on the application.

Aggregate

Fine aggregate used for cement mortar should be properly graded to give minimum void ratio and be free from deleterious materials like clay, slit content and chloride contamination etc., Normal weight fine aggregate clean, hard, and strong free of organic impurities and deleterious substances and relatively free of silt and clay. It was sieved through 4.75mm sieve. The fineness modulus of the fine aggregate is 2.51 and specific gravity of fine aggregate is 2.56. Locally available blue metals were used. Crushed granite stones of size passing through 20mm sieve and retained on 4.75 mm sieve as per IS: 383-1970 was used for experimental purposes.

Water

Water is an important ingredient of concrete as it chemically participates in the reaction with cement to form the hydration product, C-S-H gel. The strength of cement mortar depends mainly from the biding action of the hydrated cement paste gel. A higher w/c ratio will decrease the strength, durability, water – tightness and other related properties. Water conforming to the requirement of BIS: 456 – 2000 is found to be suitable for making CM. It is generally stated that water fit for drinking is fit for making CM.

Wire Mesh

Mild steel welded wire mesh layers of 2mm diameter and 25mm spacing of wire mesh. Square mesh is used in this experiment. Steel meshes for Ferro cement includes square woven or square welded mesh and chicken wire mesh of hexagonal shape and expanded metal mesh. Some mesh filaments are galvanized. Properties of the resulting Ferro cement product can be expected to be affected by mesh size, ductility, manufacture and treatment.

Wire mesh

Properties of Ferro cement Composites

- Wire diameter 0.5 to 1.5 millimetres.
- Size of mesh opening 6 to 35 millimetres.
- Maximum use of 12 layers of mesh per inch of thickness.
- Maximum 8% volume fraction in both directions.
- Maximum 10 square inches per cubic inch in both directions.
- Thickness 6 to 50 millimetres.
- Steel cover 1.5 to 5 millimetres.

Applications of Ferro cement Composites

- Water Tanks
- Canal linings
- Aqueducts
- Pipes
- Ferro cement gates

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- Culverts

Advantages on the Construction side

- It can be fabricated into almost any shape
- Skill needed for the construction can easily be acquired
- Heavy plant and machinery is not required
- Easy to repair

Table 1. Mix proportion

MIX RATIO	WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
FERROCEMENT PANEL	0.45	1	3	0
RCC Slab	0.5	1	1.49	3.36

RESULTS AND DISCUSSION

The experimental results of the flexural behaviour of Ferro cement composite slabs have been discussed in this chapter. Also a comparison on the maximum load carrying capacity and deflection has been made. Supporting graphs have been attached. The experimental results are compared with RCC slab result.

Tensile strength of wire mesh

The Ferro cement reinforcement was a welded square wire mesh of 2 mm diameter and 25 mm openings. The tensile strength of the mesh was found using the method proposed by ACI Committee. Three specimens taken from the longitudinal direction of the mesh were tested. The average yield strength was found to be 390 N/mm^2.

Compressive strength of cube specimens

6 Cubes of size 150 mm x 150 mm x 150 mm, and 6 Cubes of size 70.6 mm x 70.6 mm x 70.6 mm, were cast along with the slab as control specimens were cast. These specimens were moist cured for 7 and 28 days and tested for strength in compression with capacity of 100 tonnes. The load was applied as per IS: 516 – 1964. The average compressive strengths are tabulated in Table 2 for mortar and Table 3 for concrete cubes.

Table 2. Compressive Strength of Mortar Cubes

Mortar cubes	7 Days N/mm^2	28 Days N/mm^2
1	19.79	29.42
2	19.56	29.50
3	18.50	28.56
Average value	19.28	29.16

Table 3. Compressive Strength of Concrete Cubes

Concrete cubes	7 Days N/mm^2	28 Days N/mm^2
1	15.11	24
2	15.37	24.17
3	16.04	23.55
Average value	15.50	24.08

Flexure Test on Ferro cement panel

Ferro cement specimens were tested in accordance with the applicable provision standard testing methods for flexural strength of Ferro cement, using a fixed supported slab. The flexural strength test under two point loading was conducted on all the panels. During the testing loads and the corresponding deflections are noted down and are presented here in the forms of tables and graphs. The flexural strength was also calculated and shown here.

Table 4. Flexural Strength of Ferro cement Panel

Types of loading	Load carrying capacity IN (N)	Flexural strength (N/mm^2)
Two point loading	4100	9.42

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Centre point loading	3000	6.89

Table 5. Flexural Strength of RCC Slab

Load in KN	0	5	10	15	20	25	30	35
Deflection of slab1 in mm	0	0.5	0.87	1.35	1.857	4.114	6.763	8.57
Deflection of slab2 in mm	0	0.515	0.869	1.349	1.857	4.057	6.76	8.48

Chart 1. Load vs Deflection curve for RCC Slab 1

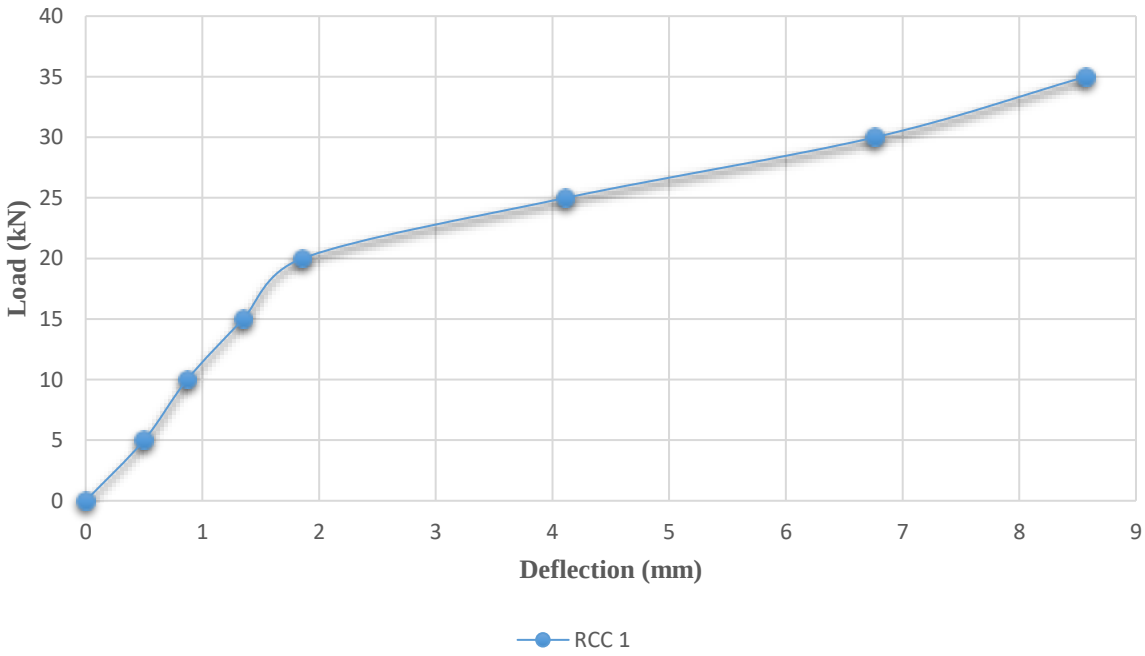

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Chart 2. Load vs Deflection curve for RCC Slab 2

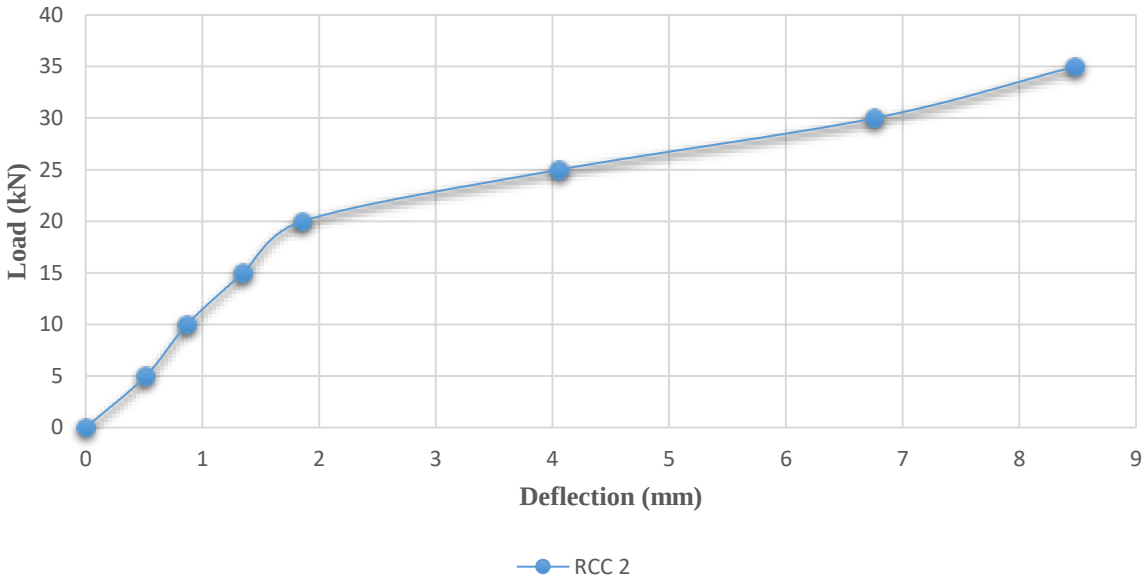

Table 6. Flexural Strength of Composite Slab

Load in KN	0	5	10	12	12	15	20	25	30	35
Deflection of slab1	0	0.5	0.88	1.1	1.4	1.65	1.9	3.2	6.1	7.9
Deflection of slab2	0	0.58	1.02	1.22	1.52	1.68	2.02	3.9	6.7	8.6

Chart 3. Load vs Deflection curve for composite slab 1

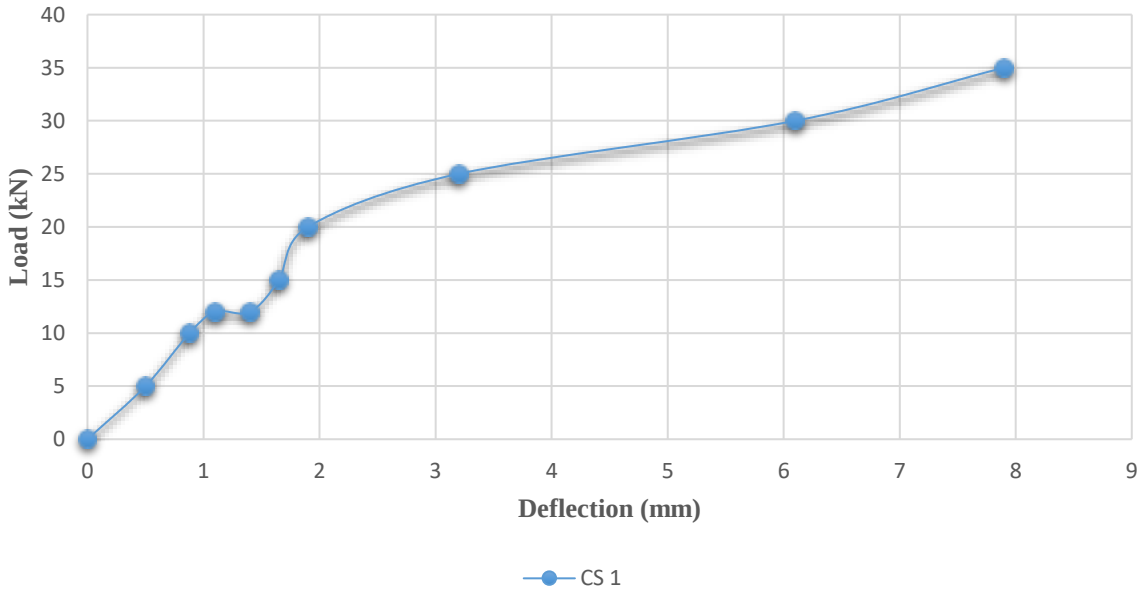

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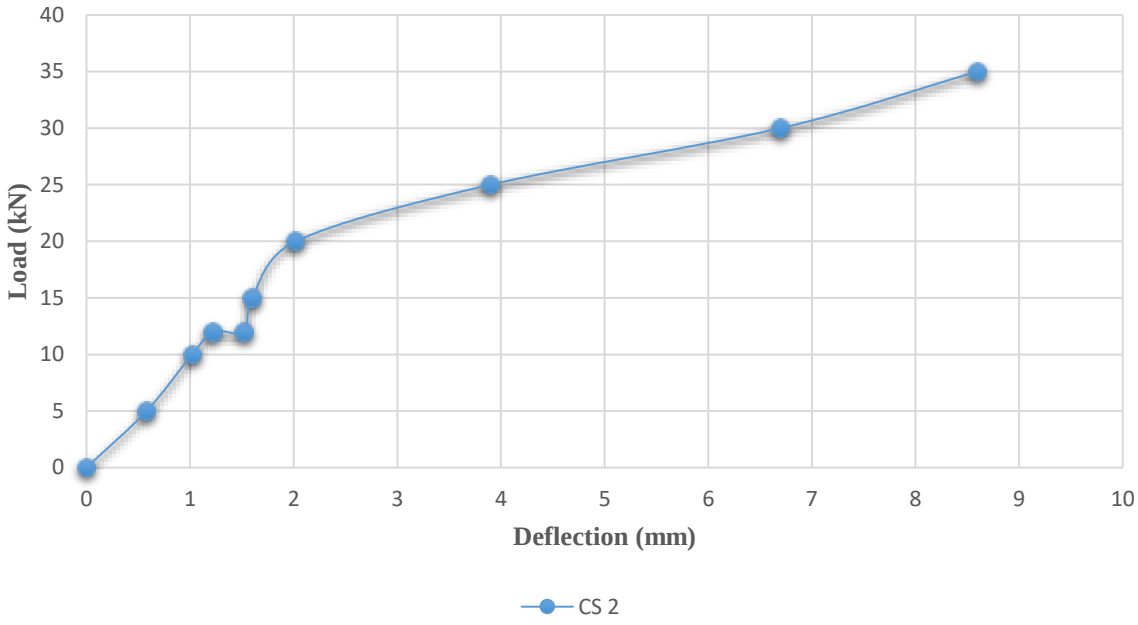
Chart 4. Load vs Deflection curve for composite slab 2



CONCLUSION

This paper proves that reinforced concrete slabs with Ferro cement tension zone cover is superior in crack control, stiffness and first crack moment to similar slabs with normal concrete cover. Construction costs with Ferro cement cover will, of course, be higher. However, this could be greatly offset by sparing millions of pounds spent on repairing damaged structures caused by cracked or spelled normal concrete covers. Moreover, it allows existing conventional concrete materials and practices to be used. Further research work will be required to investigate the use of Ferro cement cover for other applications, especially the use of deep covers, usually advocated in corrosive conditions, without giving rise to wide surface cracks.

Within the range of the variables covered by the present study, the following conclusions may be drawn:

- The fibrocement structural elements involved in this study are having a simple cross section and it can be fabricated easily with the help of simple formwork.
- Increasing the number of steel mesh layers from 1 to 3 caused a substantial increase in flexural strength and energy absorption to failure.
- The preliminary investigation reported in this study indicates that Ferro cement cover can be successfully used for reinforced concrete slabs.
- Crack width of the tested reinforced concrete slabs was considerably narrowed by the use of Ferro cement. Specimens with Ferro cement cover showed higher stiffness and higher cracking moment than those with normal concrete cover. Deflection near service load was significantly reduced in the specimens with Ferro cement cover.
- A slight improvement in the bending capacity of the specimens with Ferro cement cover was observed
- Full composite action can be achieved by shear connecter used to inter connect between the shear loading panel of Ferro cement slab, then it increases the shear behaviour.

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