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EXPERIMENTAL STUDY ON FLEXURAL BEHAVIOUR OF FERROCEMENT COMPOSITE SLAB

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ABSTRACT This project deals with an experimental programme to understood the flexural behaviour of a ferrocement composite slabs under mid third loading. The concept of composite slabs profited shut decking or shear connectors are well established. But still, in countries like India, the application of same is limited due to difficulties in fabrication and also due to concerns like fire resistance durability aesthetics etc. A attempt to exploit the concept of steel – concrete composite to a similar system in which steel sheeting is replaced by ferrocement elements. It will act as permanent form work and also participating in the structural performance of the slab.

Key words: Ferrocement, steel-concrete composite, form work, flexural behaviour.

1. INTRODUCTION

With an increased demand for the building infrastructure at economical cost, it has lead to use the available materials in an efficient way. The basic idea is utilization of the material strength possessed in it. Today's structures are situated in more aggressive environment. The most extensively used building medium in the world today is concrete and steel combined to make reinforced concrete; familiar uses are in high-rise buildings, highway bridges, and roadways. Yet, the first known example of reinforced concrete was a ferrocement boat. Reinforced concrete developed as the material familiar today in fairly massive structures for which formwork to hold the fresh concrete in the wide gaps between reinforcing rods and a fairly thick cover over the rods nearest the surface are required, he observed that reinforcing concrete with layers of wire mesh produced a material possessing the mechanical characteristics of an approximately homogenous material and capable of resisting high impact. Thin slabs of concrete reinforced in this manner proved to be flexible, elastic, and exceptionally strong.

Several reasons for the widespread use of ferrocement are (i) 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. (ii) On the material side: Toughness, Ductility, Durability, Strength, Cracking resistance. The disadvantages of ferrocement construction are, large, internally unsupported domes and curved roofs have been built that could not have been constructed with other materials without elaborate ribs, trusses, and tie rods. The large amount of labour required for ferrocement construction is a disadvantage in countries where the cost of unskilled or semi-skilled labour is high. Tying the rods and mesh together is especially tedious and time consuming.

2. LITERATURE REVIEW

The literature study for this report is as follows, Perumal. P, reported on the flexural behaviour of ferrocement under four points loading and its behaviour under accelerated corrosion test were studied. 16 slabs of 4 different thicknesses for accelerated corrosion test and a total of 12 cubes to find out the characteristic strength of mortar used were cast and tested. He has reported on the thickness of ferrocement slab increases, the ratio of collapse load to 1st crack load also increases. The failure of ferrocement is more related to concrete failure.

C.B. Kameswara Rao and A. Kamasundara Rao, reported on stress-strain relation for ferrocement in tension. Hollow cylindrical specimens were investigated using three cement mortar mixes and seven types of meshes. The specimens were designated with type of mesh, nominal value of specific surface, factor and type of mix. They were analyzed as thick cylinder subjected to internal fluid pressure. A rectangular hyperbola was formed when the relation between the ratio of load carrying capacity of ferrocement at cracking to the yield load wires and specific surface factor was plotted. Stress-strain diagram upto ultimate can be generated for any given set of parameters for ferrocement in tension. They found that stress-strain behavior is continuously non-linear up to ultimate except in the very initial stages and the relative contribution of mortar to the tensile strength of ferrocement decreases with the increase in strain level.

M.A. Al-Kubaisy , Mohd Zamin Jumaat, discussed a study on flexural behaviour of reinforced concrete slabs with ferrocement tension zone cover. The results of tests on 12 simply supported slabs are presented.. The presence of a cold joint between the reinforced concrete slab and the ferrocement layer lowered the ultimate flexural load by 34%, however, cracks width and spacing were reduced. Specimens cast without structural connection, provided that concrete was cast within 1]1.5 h of casting the ferrocement cover, behaved in a very similar manner to those with structural connection. The deflections at service load and near ultimate load were smaller for specimens with ferrocement layer. The ferrocement layer thickness and the connection type influenced the reduction in deflection

Z.Reichverger and I.Soroka investigates ferrocement with a grouped reinforcement. In order to avoid the possible displacement of the reinforcement meshes and there by reduces the risk of corrosion , it is suggested to place the meshes in two separate groups at the bottom and top of the cross section of Ferro cement elements, with the meshes in each group being placed directly one on top of the other. The tests involved some 20 different series and indicated that the grouping of the reinforcement essentially did not affect the behaviour of Ferro cement element subjected to tension.

M.A.Mansur, Mohamed Maalej and Mohammad Ismail, discussed a study on corrosion durability of ferrocement. Experimental program has been designed to establish a suitable protective system against reinforcement corrosion in thin walled ferro cement structure. Distributed and evenly dispersed reinforcement elements in ferro cement compared with traditional reinforced concrete, accumulation of rust around the fine wire resulted in the development of bursting pressure sufficient to generate cracking.

S.K.Kaushik, D.N.Trikha and R.R.Kodawala 1982, discussed a study of simply supported and the restrained ferrocement beams. 20 laboratory sizes of ferrocement strips, beams, and lintels were tested to study the effects of mesh reinforcement on the ductility, cracking and moment. The moment of resistance and the ultimate rotation decrease with the increase in volume fraction of the mesh. The max observed crack width at the mid span of the restrained beam decreased by 30 to 40% as compared to the simply supported beam.

3. MATERIALS USED

The materials used for this report were cement of OPC 53 grade, fine aggregate of fineness modulus as 2.51 and specific gravity of 2.56, crushed granite stones of size passing through 20mm sieve and retained on 4.75 mm sieve, and mild steel welded wire mesh layers of 2mm diameter and 25mm spacing of wire mesh.

Fig No. 1 Wire Mesh

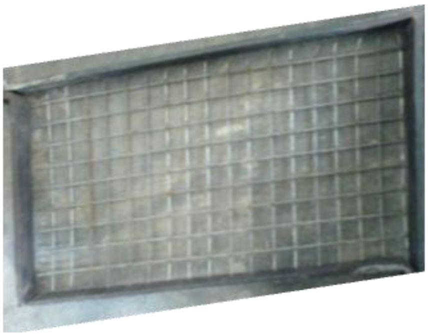
4. EXPERIMENTAL INVESTIGATION

The test programme consists primarily of tests to determine the flexural behaviour of RCC slab when subjected to two point load, and also to determine the variation in flexural behaviour with composite slab. In the present investigation, tests were conducted on 2 RCC Slab and 2 composite slabs. Ferrocement panel is casted with one layers of welded wire mesh. The variables chosen are the percentage of reinforcement and the number of mesh layers keeping all other parameters such as span, w/c ratio, curing period etc. Throughout the current investigation the cement sand ratio was kept 1:3 and water cement ratio as 0.45. The values below are used for calculating the important parameters required for making the ferrocement composite slab model.

Size of ferrocement panels	: 330mmx200mm
Thickness of ferrocement panels	: 24mm
Size of weld mesh	: 12.5mmx12.5mm
Mesh diameter	: 2mm
No. of weld mesh layer	: 1 layer
Edge conditions	: simply supported
Load setup	: two point load
Mesh type	: square mesh
Loading conditions	: 1/3 of the span from left and right end
Size of composite slab	: 330mmx1000mm

Various steps involved in the specimen preparation were given below:

The specimens were made in steel of 24mm thick with their top and bottom open. The mould was made in such a way that two edges connected with bolt so that it could be easily separated from ferrocement element after its initial setting. The inner dimension of the steel mould was 330mm x 200 mm x 24 mm. Specimens for composite slab were made in plywood with their top and bottom open. The inner dimension of the plywood mould was 330mm x 1000 mm x 150 mm. The steel moulds were greased before casting the specimen to ease of the dismantling process.



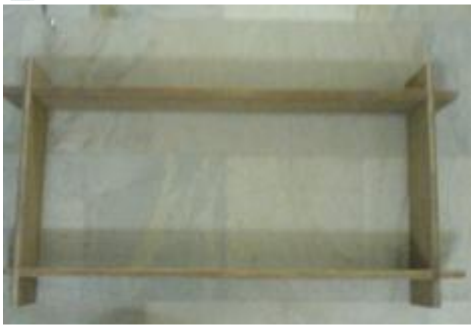


Fig No. 2 Specimen Moulds

Placing of wire mesh at the center of the ferrocement panel (24mm).and preparing of cement mortar at the ratio of 1:3 with 0.45 % w/c ratio. After that cement mortar is placed inside the ferrocement panel and then compacted & well finished. 20 numbers of Shear connector is connected in wire mesh at 250mm spacing for 10 numbers of ferrocement panels. 5 numbers of ferrocement panels is arranged horizontally and shear connector is connected with main reinforcement of RCC slab. Then ordinary concrete is placed above the ferrocement panel and it is compacted & well finished.

Fig No. 3 Ferro cement Slab & RCC Slab Panels

Mix proportions of both RCC slab and ferrocement panel are as shown below,

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

The specimens casted, were left in the moulds for 24 hours. After that identification was marked on the exposed face of the specimens, the specimens were demoulded, and immediately placed under water in a curing tank. The specimens were allowed to cure under water for a period of 28 days.

The composite slabs and RCC slab along with the cubes cast from the same mortar were taken out of the curing tank at the age of 28 days and their surfaces were cleaned, for removing any salt deposits. They were allowed to dry in room temperature for a minimum of three hours. The actual dimensions of the specimens were accurately measured and noted, the weights of the specimens were found out. All the specimens were given a thin coat of janathacem, in order to facilitate, easy detection of formation of first crack. Centre lines, load positions, support points and dial gauge positions were marked using pencil in the appropriate places.

5. RESULTS AND DISCUSSIONS

The ferrocement 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 as shown below.

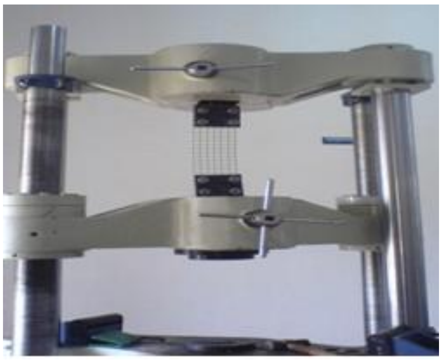


Fig No. 5 Testing of wire mesh

Compressive strengths tests were conducted on cube specimens using compressive testing machine of capacity 100 tonnes. The load was applied as per IS: 516 – 1964. Six numbers of 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. These specimens were moist cured for 7 and 28 days and tested for strength in compression. The average compressive strengths are tabulated.

Table No. 2 Compressive Strength values of Concrete and 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
AVG VALUE	19.28	29.16

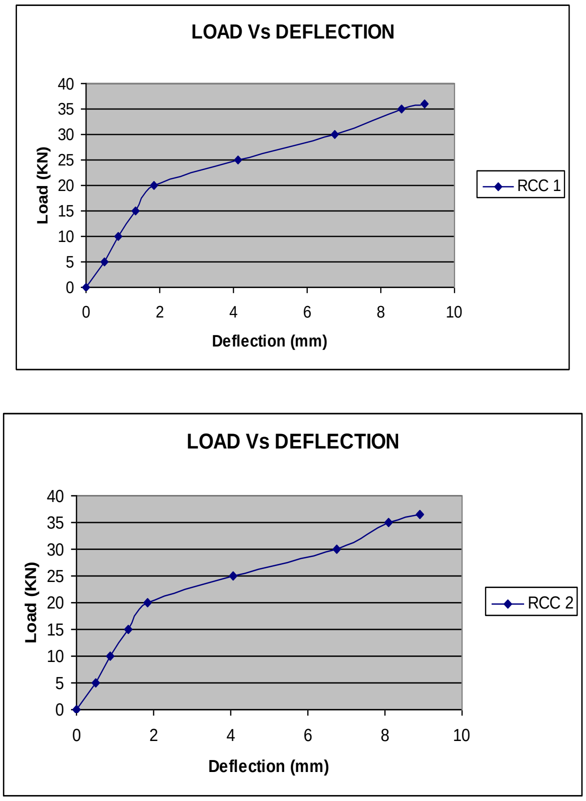
The load carrying capacity and deflection of Ferro cement composite slab and RCC slab are tabulated as follows,

Table No. 3 Flexural Strength of Ferrocement Panel

TYPES OF LOADING	LOAD CARRYING CAPACITY (N)	FLEXTURAL STRENGTH (N/mm^2)
TWO POINT LOADING	4100	9.42
CENTRE POINT LOADING	3000	6.89

Table No. 4 Flexural Strength of RCC Slab

Load in KN	0	5	10	15	20	25	30	35
Deflection of slab1 mm	0	0.5	0.87	1.35	1.857	4.114	6.763	8.57
flection of lab2 mm	0	0.515	0.869	1.349	1.857	4.057	6.76	8.48



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
AVG VALUE	15.50	24.08

Fig No. 6 Load vs Deflection curve for RCC Slab 1 & RCC Slab 2

Fig No. 7 Load vs Deflection curve for composite slab 1 & composite slab 2

Fig No. 8 Test setup of ferrocement panel and RCC Slab

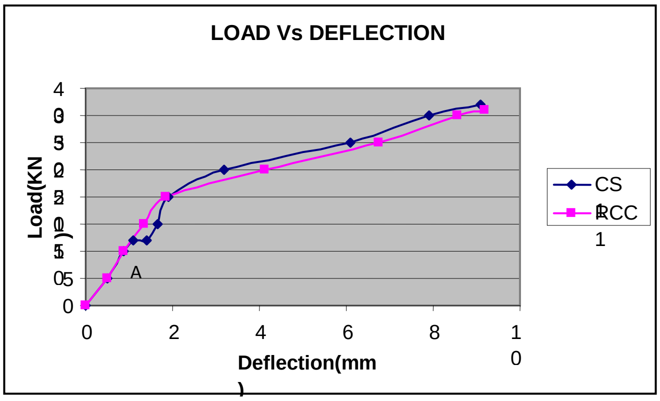


Fig No. 9 Comparison of RCC Slab and Composite Slab

6. CONCLUSION

This paper proves that reinforced concrete slabs with ferrocement tension zone cover is superior in crack control, stiffness and first crack moment to similar slabs with normal concrete cover. Construction costs with ferrocement 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 ferrocement 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 preliminary investigation reported in this study indicates that ferrocement cover can be successfully used for reinforced concrete slabs.
- ❖ Crack width of the tested reinforced concrete slabs was considerably narrowed by the use of ferrocement. Specimens with ferrocement 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 ferrocement cover.
- ❖ A slight improvement in the bending capacity of the specimens with ferrocement cover was observed
- ❖ Full composite action can be achieved by shear connecter used to inter connect between the shear loading panel of ferrocement slab, then it increases the shear behaviour.

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