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# Study on Flexural Behavior of Flat Ferrocement Panels

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**Abstract:** ***Prefabricated elements are used in construction industry as an alternative system to overcome the formwork problems in addition to getting better quality control. The prefabricated elements made of reinforced concrete are extremely heavy and difficult to transport, placing in position and to construct. Alternatively, ferrocement panels are being used in construction industry due to its good structural performance and low cost. Ferrocement is suitable for the construction of roofing/floor elements, precast units, manhole covers, and construction of domes, vaults, grid surface and folded plates. It can also be used for making water tanks, boats, and silos. An experimental investigation on flexural behavior of flat ferrocement panels reinforced with skeletal steel and galvanized iron wire mesh with varying number of wire mesh layers is presented. The slabs are tested under flexural loading by applying line loads at 1/3$^{rd}$ points. It is concluded that the first crack and ultimate loads increase with the increases number of layer wire mesh. From the studies, it is observed that the load carrying capacities, deformation at ultimate load and energy absorption capacities are high in the case of increasing the number of wire mesh layers. Further, it is observed that there is a reduction in crack width and increase in number of cracks indicates are delay in crack growth.***

**Keywords*:*** ferrocement, flexural strength, wire mesh, deflection

## 1. Introduction

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 which may be made of metallic or other suitable materials. Since ferrocement possess certain unique properties, such as high tensile strength-to-weight ratio, superior cracking behavior, lightweight, mold ability to any shape and certain advantages such as utilization of only locally available materials and semi-skilled labor/workmanship, it has been considered to an attractive material and a material of good promise and potential by the construction industry, especially in developing countries. It has wide range of applications such as in the manufacture of boats, barges, prefabricated housing units, biogas structures, silos, tanks, and recently in the repair and strengthening of structures.

Ferrocement is suitable for low-cost roofing, pre-cast units and man-hole covers. It is used for the construction of domes, vaults, grid surfaces and folded plates. It can be used for making water tanks, boats, and silos. Ferrocement is the best alternative to concrete and steel. Generally, ferrocement shells range from 10 mm to 60 mm in thickness and the reinforcement consists of layers of steel mesh usually with steel reinforcing bars sandwiched midway between. The resulting shell or panel of mesh is impregnated with an extraordinarily rich (high ratio of cement to sand) Portland cement mortar.

Ferrocement is a highly versatile construction material and possess high performance characteristic, especially in cracking, strength, ductility, and impact resistance. As its reinforcement is uniformly distributed in the longitudinal and transverse directions and closely spaced through the thickness of the section. There is an ample scope for mass production and standardization together with the economy in construction.

## 2. Experimental Program

### 2.1 Material properties

The following materials are used in this work:

- Ordinary Portland cement
- Fine aggregate
- Chicken meshes-Hexagonal opening
- Weld meshes-Rectangular grid opening

**Cement:**

Ordinary Portland cement of grade 53was used to prepare control and test specimens. Some of the properties of the cement are:

Specific gravity = 3.15, Standard consistency = 34% Initial setting time = 40 mins

Compressive strength = 52.16 N/mm$^2$

**Fine Aggregate**

Fine aggregate used is the river sand obtained from Trichy passing through 4.75 mm IS sieve with a specific gravity of 2.62 and having a fineness modulus of 2.80 (IS 383-1971 Zone II)

**Wire Mesh**

Galvanized chicken wire mesh with a hexagonal opening of size 12mm and a wire thickness of 1.29mm was used.


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**Figure 1:** Chicken Mesh

**Skeletal Reinforcement**

The mild steel having diameter of 6 mm @ 100 mm c/c in transverse and in the longitudinal direction was used**.**



**Figure 2: S**keletal reinforcement

**Water**

Potable drinking water was used for mixing and as well as for curing

**Super Plasticizer**

Super plasticizer-Conplast SP430 from Fosroc was added to improve the workability of fresh mortar.

**2.2 Geometry of the Specimens**

The dimensions of flat ferrocement panels are 1000 mm x 350 mm x 30mm.The reference number and designations of the tested elements are given table. The panels are constructed using the conventional ferrocement materials, which is composed of cement mortar and hexagonal wire mesh.

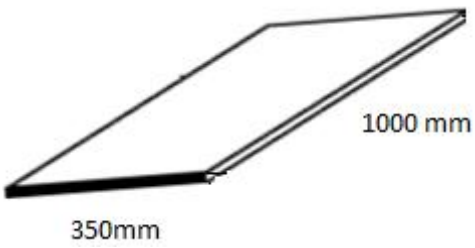



**Figure 3:** (a) Dimensions of flat panel

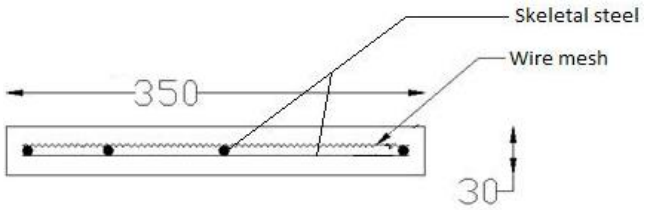



**Figure 3:** (b) Flat slab with single layer mesh (FP-FT 01)

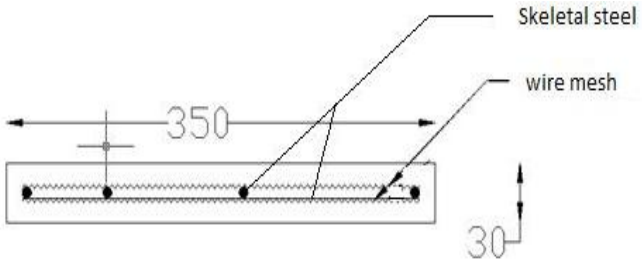



**Figure 3:** (c) Flat slab with double layer mesh (FP-FT 02)
**Figure 3:** Geometry of flat ferrocement panel

**2.3 Preparation of Test Specimens**

The panels were cast using the conventional ferrocement materials, which is composed of cement mortar and hexagonal wire mesh. Two type slabs of size 1000 mm x 350 mm x 30 mm were cast in steel mould. One type is the slab with one layer of chicken mesh and another is with two layer of chicken mesh and the skeletal rods were bundled with binding wire and placed in the mold keeping a minimum cover of 5mm.Then cement mortar (Type 3) is poured into the mould. For each specimen, 3 mortar cubes of size 70.7 mm x 70.7 mm x 70.7 mm are cast to test the characteristic strength of the mortar mix. After 24 hours from casting, the samples are removed from the mould and cured in water for 28 days.



**Figure 4:** Casting of Control Specimens



**Figure 5:** Fabrication of Slab Mould


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**Figure 6:** Test Setup




**Figure 7:** Testing of slab FP-FT 01



**Figure 8:** Testing of slab FP-FT 02

### 2.4. Testing of Specimens

The slab was tested under loading frame. The load was applied by means of a Load Cell of 50 ton capacity. The specimens were tested by simulating simply supported conditions. The load was applied as two symmetrically arranged concentrated line loads. Loading is applied using a Hydraulic Jack and LVDT was fixed at central bottom to measure the deflection. The slabs were painted using whitecem to help in tracing the cracks. The test setup is shown in figure (6). The load is applied in small increments and simultaneously the deflection at the center of the panel was recorded during the loading process up to failure. The deflection at the mid span is measured by LVDT. Cracking pattern was carefully checked throughout the loading process and the corresponding cracking load is also noted.

**Table 1:** Mix proportions

| S. No. | C/S Ratio | W/C Ratio | Super Plasticizer (%) | Compressive Strength (N/mm2) |
|---|---|---|---|---|
| 1 | 1.3 | 0.3 | 1 | 42.50 |
| 2 | 1:2 | 0.3 | 1 | 47.25 |
| 3 | 1:1 | 0.3 | 1 | 52.16 |

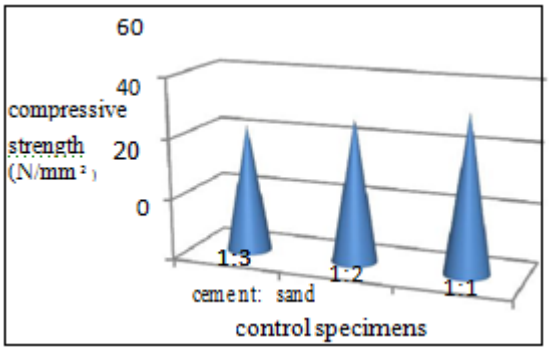



**Figure 9:** Compressive strength of control specimens

**Table 2:** Experimental Results

| | *Cracking* | | *Ultimate* | |
|---|---|---|---|---|
| *Specimen ID* | *Load (kN)* | *Deflection (mm)* | *Load (kN)* | *Deflection (mm)* |
| FP-FT 01 | 1.00 | 1.9 | 1.9 | 28.6 |
| FP-FT 02 | 1.90 | 13.6 | 2.8 | 27.5 |

## 3. Results and Discussion

The parameters that have been investigated in this study is the effect of the geometry of the panels and number of wire mesh layers on the cracking load and ultimate flexural strength and the plot of load deflection curve for panel. The test results are presented in the below table (2) in which cracking and ultimate load for the tested ferrocement panels are summarized. The gain in the ultimate strengths with the increase in the number of wire meshes layers for the panels. The failure load increased from 1.9KN for FP-FT01 to 2.8KN for FP-FT02.

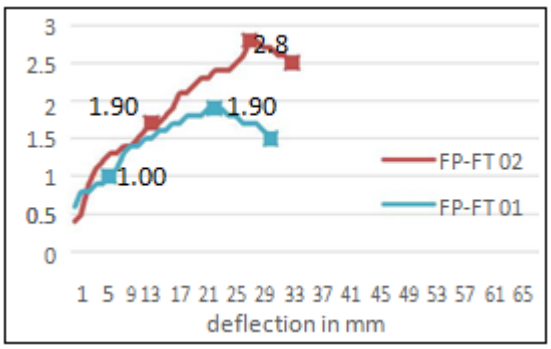



**Figure 10:** Load- Deflection Curves flat panels


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**Figure 11:** (a) Crack Pattern (FP-FT01)



**Figure 12: (**b) Crack Pattern (FP- FT02)

### 3.1 Cracking Behavior

The failure of the slab specimen's results from the yielding of wire mesh reinforcement is followed by the crushing of mortar. Initially fine flexural cracks appeared at the bottom of the specimen. With further increase in the load, regularly spaced vertical cracks were observed and they extended from the bottom of the specimen towards the top (Figure11).The load was increased up to ultimate stage and cracking pattern were observed.

## 4. Conclusions

Based upon the experimental test result of the flat panel, the following conclusions were made:

- The cracking load was not significantly affected by the number of the wire mesh layer particularly for the flat panel.
- From the experimental results, the flexural strength of flat panel with single wire mesh layer is 81% lower than trough panel and 91% lower than folded panel.
- And flat panel with double layer wire mesh is 77.95 % lower than trough panel and 89% lower than folded panel. And the deflection is reduced by 56.36% and 2 % respectively when compared of trough panel and folded panel.
- Finally increasing the number of layers of wire mesh from single and double layers increases the ductility in both types of the panel.

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