ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2014

Experimental Investigation on Flexural Behaviour of Folded Ferrocement Panels

Vincent Prabakar Rajaiah[1], S.Dharmar[2], Dr.S.Nagan[3]

[1]PG Scholar, Department of Civil Engineering, P.S.R. Engineering College, Sivakasi, India

[2] Assistant Professor, Department of Civil Engineering, P.S.R. Engineering College, Sivakasi, India

[3]Associate Professor, Department of Civil Engineering, Thiagarajar College of Engineering, Madurai, India

ABSTRACT: Ferrocement is a thin composite made with a cement based mortar matrix reinforced with closely spaced layers of relatively small diameter wire mesh. Over the years, applications involving ferrocement have increased due to its properties such as strength, toughness, water tightness, lightness, ductility and environmental stability. Ferrocement may be cast in various shapes and forms even without the use of form work and are aesthetically very appealing. Due to their thinness, ferrocement elements can be used as roofing, flooring elements to cover large spans. The slenderness of these elements may adversely affect their performance under working loads. Hence, there is a need to study their flexural behaviour such as first crack strength, load-deflection behaviour. The present study describes the result of testing folded ferrocement panel reinforced with number of wire mesh layer. The main aim of these experimental tests is to study the effect of folded ferrocement panel using different number of wire mesh layers on the flexural strength by varying the numbers of wire mesh layers on cracking, load deflection behaviour, ductility and ultimate flexural strength. This is useful to find solutions by searching new design techniques and method of constructions.

KEYWORDS: Ferrocement, Flexural Strength, Deflection, Wire Mesh

I. INTRODUCTION

Ferrocement is a thin composite made with a cement based mortar matrix reinforced with closely spaced layers of relatively small diameter wire mesh. Over the years, applications involving ferrocement have increased due to its properties such as strength, toughness, water tightness, lightness, ductility and environmental stability. Ferrocement may be cast in various shapes and forms even without the use of form work and are aesthetically very appealing. The success of ferrocement has been attributed to the ready availability of its component materials, the low level technology needed for its construction and relatively low cost of final products Due to their thinness, ferrocement elements can be used as roofing / flooring elements to cover large spans. The slenderness of these elements may adversely affect their performance under working loads. Hence, there is a need to study their (a) first crack strength, Mcr and (b) load-deflection (P-d) behaviour. While (a) and (b) characterize the serviceability behaviour of ferrocement elements, it is equally important to predict their flexural strength Mu one of the ultimate limit states. A number of investigations are available for the flexural analysis and design of ferrocement members. However ferrocement elements do form cracks under certain loads much smaller than the ultimate load and have a durability problem when unmodified cement mortar is used [2]. Durability of a structure is its resistance to weathering action, abrasion, chemical attack, cracking or any other process of destruction [3]. Corrosion of reinforcement is one of the major reasons for deterioration of ferrocement. The corrosion of reinforcement mainly depends upon the permeability of the cement mortar. So by proper selection of chemical and mineral additives, water cement ratio of ferrocement mortar can be reduced. This in turn reduces the pore size, there by achieving very high strength levels and durability [4] and the flexural moment capacity of ferrocement elements increases with the volume fraction of reinforcement [5]. Therefore the authors have conducted this investigation to improve the flexural behaviour and durability of ferrocement using modified mortar matrices. The objective of this investigation is to determine experimentally the corrosion performance of reinforcement in ferrocement beams subjected to an impressed current and a high salinity solution. This paper deals with the study of the ultimate strength of precast ferrocement roofing / flooring elements. In the present study folded shaped ferrocement elements and prototype roofing elements were cast and tested.

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II. EXPERIMENTAL INVESTIGATION

2.1 Material Characterization

2.1.1 Cement

Ordinary Portland cement of grade 53 is used in the mortar matrix and to prepare control 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.

2.1.2 Sand

Fine aggregate used is Trichy River Sand passing through sieve in 4.75mm with specific gravity of 2.62 and having a fineness modulus of 2.80 (IS 383-1971 Zone II)

2.1.3 Super Plasticizer

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

2.1.4 Water:

Potable Water was used for mixing and as well as for curing.

2.1.5 Skeletal Steel

Skeletal rod used in the present work is mild steel having 6mm diameter @ 100mm c/c both in transverse and longitudinal directions. The ultimate tensile strength of mild steel is 472 N/mm^2

.2.1.6 Wire mesh

Steel wire meshes are considered as primary reinforcement. This include square woven or welded meshes, chicken (hexagonal/aviary) wire mesh, expanded metal mesh, etc. Except for expanded metal mesh, generally all the meshes are used galvanized. Galvanized Chicken wire mesh with a hexagonal opening of size 12mm and wire thickness of 1.29 mm was used in this study.

2.2 Geometry of the Specimens

The geometry of the panel is folded shape as shown with dimensions 1000 mm x 400 mm x 30 mm.The panels are constructed using the conventional ferrocement materials, which is composed of cement mortar and hexagonal wire mesh.

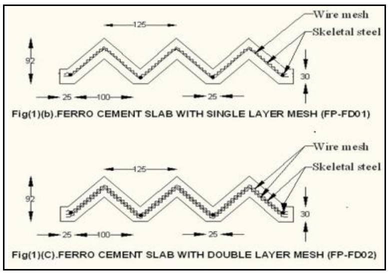

Fig (1): Geometry of folded panel

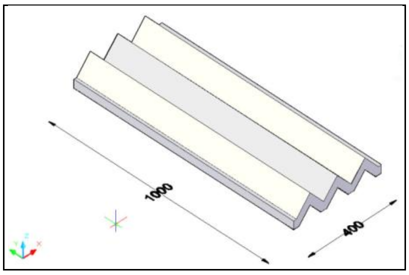

Fig (1) (a): Dimensions of folded panel

2.2.1 Casting of control specimens

Cement mortar cubes of size 70.7 mm × 70.7 mm × 70.7 mm are cast to test characterize the strength of the mortar mix.

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Fig (2): Casting of control specimens

2.2.2 Casting and curing of folded panels

Special mould was fabricated in metal sheet to match the required geometry of the folded panel. Each sample is molded after fixing the required wire mesh and skeletal steel in its proper position. For the panels with single wire mesh, the wire mesh was placed at mid depth of the panel and the panels with double wire mesh, the wire meshes are placed on two sides of the skeletal steel. Then the panels were cast in mortar mix of 1:1 and water-cement ratio of 0.3 with proper compaction. After 24 hours of casting, the samples are removed from the mould and cured in water for 28 days.

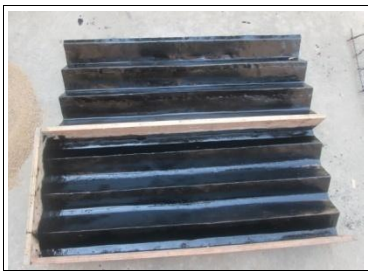

Fig (4): Fabrication of mould Fig (5): Wire Mesh Fig (6): Skeletal Steel

Fig (7): Casting Fig (7) (a): Curing of panels

2.2.3. Testing of Specimens

All the panels were tested under loading frame. The load was applied by means of a load cell of 50 ton capacity. All the specimens were tested by simulating simply supported conditions. The load was applied as two symmetrically arranged concentrated line loads. Loading was applied using a Hydraulic Jack of 50 ton capacity. The Dial Gauge of 0.01 mm least count and 50 mm range was fixed at central bottom to measure the deflection. The panels were painted using white cem to help in tracing the cracks. The load was applied in small increments and simultaneously the deflection at the centre of the panel was recorded during the loading process up to failure. The deflection at the mid span is

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measured by Dial Gauge having accuracy to 0.01mm.Cracking was carefully checked throughout the loading process and the corresponding cracking load was also noted.



Fig (8): Test Setup

Fig (9) (a): Testing of folded panel FP-FD 01

Fig (9) (b): Testing of folded panel FP-FD 02

Fig (9): Testing of folded panels

III. RESULTS AND DISCUSSION

The parameters that have been investigated in this study are the effect of the geometry of the panels and number of wire mesh layers on cracking load and ultimate flexural strength and plot of load deflection curve for each panel. The test results are presented in the below table, in which cracking and ultimate load for the tested ferrocement panels are summarized. The cracking load is almost constant for the folded panels and it was not affected by the number of wire mesh layers. The load deflection curves for the folded panels that increasing the number of wire mesh layers from 1 and 2 causes to increase the ultimate load from 20KN to 27.5KN. The percentage increases in the load capacity of panel FP-FD 02 with respect to FP-FD 01 is in order of 38% respectively.

Table (1) Mix Design of control specimen's cube.

Cube Specimens	**C/S Ratio**	**W/C Ratio**	**Super plasticizer (%)**	**Compressive Strength (N/mm^2)**
1	1.3	0.3	1	42.50
2	1:2	0.3	1	47.25
3	1:1	0.3	1	52.16

Table (2) Experimental results

Specimen Id	**Cracking**		**Ultimate**		**Failure**	
	Load (kN)	Deflection (mm)	Load (kN)	Deflection (mm)	Load (kN)	Deflection (mm)
FP-FD 01	10	2.9	20	6.14	16.7	17.49
FP-FD 02	10.5	2.8	27.5	12.79	17	7.62

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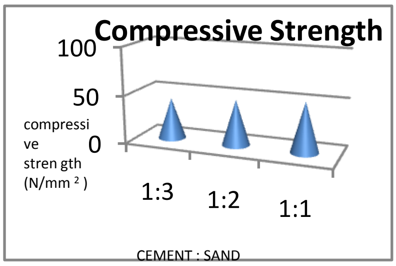

Fig (10): Compressive strength

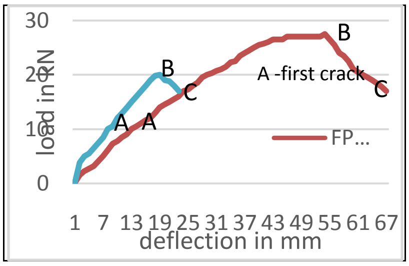

Fig (11): Load- Deflection curve

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 (Fig.12).The load was increased up to ultimate stage and cracking pattern is observed.

Fig (12) (a): Crack pattern FP-FD 01 Fig (12) (b): Crack pattern FP-FD 02

Fig (12) Crack Study

IV.CONCLUSIONS

The following conclusions were drawn from the experimental study carried out on folded shaped ferrocement panels.

- The cracking load was not significantly affected by the number of the wire mesh layer particularly for the folded panels.
- From the experimental result, the flexural strength of the folded shaped panel with single layer wire mesh is higher than 91% and 50% respectively when compared with flat and trough panel. The deflection at ultimate load is reduced by 79% and 44% respectively when compared of flat panel and trough panel.
- Folded panel with double layer wire mesh is higher than 89% and 54% respectively when compared with flat and trough panel. The deflection is reduced by 54% and increased by 6% respectively when compared of flat panel and trough panel.
- The experimental results show the superiority of the folded panels to the flat panel and trough panels in terms of ultimate strength and initiation of cracking. of layers of wire mesh from 1 to 2
- Finally increasing the number layers significantly increases the ductility and capability to absorb energy of both types of the panel.

V. ACKNOWLEDGMENTS

We deem it a privilege to express my sincere and heartfelt thanks to the author of this paper, and I also wish to express his sincere thanks to all staff members and supporting staff for their selfless support and cooperation.

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