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ResearchArticle

EFFECT OF VARIATION OF THICKNESS ON LIGHT WEIGHT FERROCEMENT PANELS: AN EXPERIMENTAL STUDY

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ABSTRACT

The Flexural strength of ferrocement panels was evaluated through laboratory investigation on flat ferrocement panels of size (550x200) mm with thickness of 20mm, 30 mm and 40mm. The mortar of 1:2.75 proportion with OPC of 53 grade and river sand of size passing through 4.75 mm IS sieve is used in this study. The water to cementitious ratio of 0.40 was maintained for all the mortars. Expanded Shape of steel Wire mesh of 1 mm thickness and opening of 15x30 mm was incorporated in the tension zone in one layer only, for this the samples were water-cured for 28 days. After that investigate the flexural strength and behaviour of ferrocement flat panels subjected to two-point loading is determined. In this study, it is observed that, the ultimate load carrying capacity of ferrocement panels goes on increasing as thickness increases. Also, the flexural strength of panel increases for 30 mm panel and decreases for 40 mm panel as compared with 20 mm ferrocement panels.

INTRODUCTION

Ferrocement is highly versatile material containing wire mesh, cement, sand and water. The wire mesh is used as reinforcement, may be woven or welded in different shapes. It is less polluting, inexpensive, generating less wastage with attractive alternative material. This technique was used in Second World War for construction of boats. From 1960s ferrocement can be used successfully for construction of building panels. World famous Sydney Opera House was constructed by ferrocement. In India, ferrocement technique has been also used for rural development with construction of small houses, farm houses etc. [M.N. Soutsos 2009 and Y. Yorozu1982].

Conventional reinforced concrete is combination of steel bars and concrete. Shuttering and scaffolding are quite essential. Ferrocement is a composition of weld mesh, mild steel angles or bars, chicken mesh and mortar. This mixture becomes a homogenous material and can be built in conditions and in any shape. Ferrocement is a very thin material that's why it becomes light in weight nature but its ductility is very high as compared to conventional RCC. Ferrocement is defined as 'Cement mortar strongly bonded and encased in layers of fine wire meshes making it a homogeneous and ductile composite'. [Y. Yorozu1982]

Definition

"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" .The mesh may be made of metallic and suitable materials. In the words of Nervi who first used the term ferrocement its notable characteristics is "Greater elasticity and resistance to cracking given to the cement mortar by the extreme subdivision and distribution of the reinforcement" [Joel Galupo Opon 2015].

Constituents of Ferrocement

The constituents of ferrocement include the hydraulic cement mortar which should be designed according to the standard mix design procedures for mortar and concrete which includes Portland cement, water, sand, wire mesh and admixtures.

Cement: The cement should be fresh of uniform consistency and free of lumps and foreign matter and of the type or grade depending on the application.

Water: Potable water is fit for use as mixing water as well as for curing ferrocement.

Fine Aggregates: Normal weight fine aggregate clean, hard, and strong free of organic impurities and deleterious substances and relatively free of silt and clay.

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Wire mesh: Steel meshes for ferrocement 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 ferrocement product can be expected to be affected by mesh size, ductility, manufacture and treatment.

Admixtures: In numerous admixtures available, chemical admixtures is best suitable for ferrocement because it reduces the reaction between matrix and galvanized reinforcement. Chemical admixtures used in ferrocement cement serve one of the following purposes like water reduction, improvement in impermeability, air entrainment, which increases resistance to freezing and thawing.

LITERATURE REVIEW

S. Deepa Shri and R. Thenmozhi[8] carried out an experimental work on ferrocement panels for studying their flexural behaviour by using polypropylene fibers. Silica fume is added to reduce the dosage of chemical admixtures needed to get required slump. It is well known that addition of fibers will generally improve the ductility, toughness, flexural strength and reduce the deflection of cementitious materials. In the present study, polypropylene fibers is added to the matrix and the dosage of fibers is taken as 0.3% by weight of cementitious materials. Weld mesh is arranged in different layers in ferrocement slab instead of reinforcement. Weld mesh of size 590 mm X 290 mm with grid size 20 mm X 20 mm and 1.2 mm dia. skeleton reinforcement is used for casting of ferrocement slabs. The slab panel size was 700mm X 300mm X 25mm and 30mm. The authors conclude that the load carrying capacity of SCC ferrocement slab panel with 0.3% fibers is larger compared to without fibers, delayed the first crack load, yield load and ultimate load compared to without and there is an increase in strength with the increase of slab thickness. Hybrid reinforced ferrocement specimens could sustain the larger deflections both at yield and ultimate loads compared to the SCC ferrocement specimens without failure. Many micro cracks are formed before failure of the specimens, indicating more energy absorption and ductility, the stiffness of the specimens with 2-layers bundled weld mesh is lower than that of the specimens with 3 layers bundled.

Mohamad N. MahmoodSura A. Majeed[5] carried out an experimental work on flat and folded ferrocement panels for studying their flexural behaviour. The panels tested for flexure are of size 380mm X 600mm with 20mm thickness for both flat as well as folded slab panels. The wire mesh used was mild steel galvanized welded wire mesh of 0.65 mm diameter and 12.5 mm square grid size. From his experimental work the author concludes that the cracking load was not significantly affected by the number of the wire mesh particularly for the folded panels. The also concludes that the flexural strength of the folded panel increased by 37 and 90 percent for panels having 2 and 3 wire mesh layers compared with that of single layer; while for the flat panel the percentage increase in the flexural strength using 2 and 3 layers is 65% and 68% compared with that of plain mortar panel.

M.N. Soutsos, T.T. Le, A.P. Lampropoulos[6] carried out an experimental project involved casting and testing 66 prisms of size 150*150*550 mm and cubes of size 100 and 150 mm. Cubes were tested for compressive strength using a Tonipact compression testing machine with maximum capacity of 3000 KN. Concrete was mixed in batch sizes of either 73 or 95 l which was sufficient for casting six 100 mm cubes for testing at 3 and 7-days, three 150 mm cubes for testing at 28-days, and six 150*150*550 mm prisms .Load–deflection curves were determined by loading the 28-day prism specimen using a Denison Avery 100 KN test machine in order to load the specimens at a constant deflection rate rather than constant load rate. Materials include CEM I Portland Cement 42.5 N, natural sand and 20–5 mm gravel. The mix proportions used were: 267 kg/m3 of Portland cement, 805 kg/m3 of sand, 1190 kg/m3 of gravel and 189 kg/m3 of water. The total water–cement ratio was 0.71. It appears that the incorporation of steel fibres increased the compressive strength by about 4 and 5 N/mm2 for fibre dosage rates of 30 kg/m3 and 50 kg/m3. The increases in the compressive strength of synthetic fibres is lower, about 2–3 N/mm2 for dosage rates of 4.5–5.3 kg/m3. Incorporation of steel fibres also appeared to increase only slightly the flexural strength, i.e. by about 0.4–0.6 N/mm2 for the plain concrete value of 4.2 N/mm2. The most important parameters for the design of ground supported slabs are the flexural toughness and the equivalent flexural strength ratio. The flexural toughness of concrete increases considerably when steel and synthetic fibres are used.

OBJECTIVE OF EXPERIMENTAL STUDY

The main objective of this experimental work is to study the behavior of ferrocement panels under flexural loading in which expanded mesh has been used as a reinforcement .The various parameters considered in this study are as follows:-

1. Effect of variation of thickness on the flexural strength of slab panels.
2. To study the flexural load-deflection curve, first crack load and ultimate load.
3. To determine the ultimate flexural strength of ferrocement panels.

Experimental Work

The experimental program includes preparing and testing of flat ferrocement slab panels under two-point loading. The primary variable is variation of thickness i.e. 20, 30 and 40mm with single layer of expanded mesh.

Materials

Cement: The cement used in the tests was Ordinary Portland Cement (Grade 53) locally available.

Fine Aggregate (Sand): Locally available clean and good graded fine aggregate was used after passing through I.S sieve 4.75 mm.

Water: Ordinary drinking water was used for mixing and curing of concrete. The water was clean and free from acids, alkalis and organic impurities.

Mesh: Expanded steel meshes were used with 15x30mm opening and thickness of 1 mm used in the specimens. It is cheap, user friendly and readily available in the open market.

Mix Proportion

The mix proportion was 1:2.75 (Cement: Sand) with water to cement ratio of 0.40. The mixing procedure is important for obtaining the required workability. Materials were mixed mechanically. Fine aggregate and cement were mixed as dry mix. Next, the water was added gradually to the mixture and the operation of mixing was continued until homogeneous concrete mix was obtained.

Casting

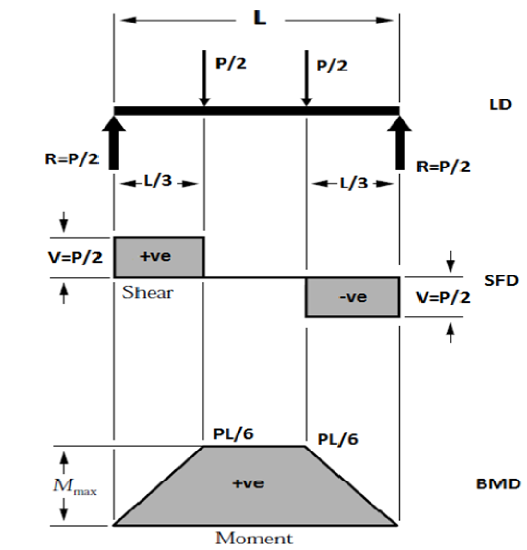
The interior faces of the moulds were oiled and then the first layer of cement mortar was poured in moulds. The first layer of mesh was laid with the cover of about 3 mm from bottom, then the mortar was placed and pouring of the mixture continued to the level of the mould and smoothened afterwards.

Curing

The test and control specimens were demoulded after 24hours, and cured according to ACI308.1. The specimens were cured for about 28days, and then left in air temperature and humidity inside the laboratory until the date of testing.

Flexural strength test

To find the flexural or bending strength of the specimen, this test is carried out .Here the flexural strength was carried out by using two point loading test.



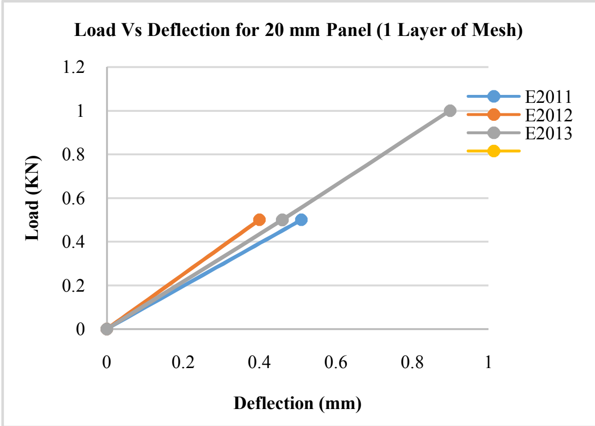
FigLoad, Shear and Bending Moment Diagrams
M/I=σ/y thus σ=M/I * y

TEST RESULTS

The parameters that had been investigated in this study are the effect of the thickness of the panels on the cracking load and ultimate flexural strength and to plot the load deflection curve for each panel.

Table I Test Results for E_{20} Samples

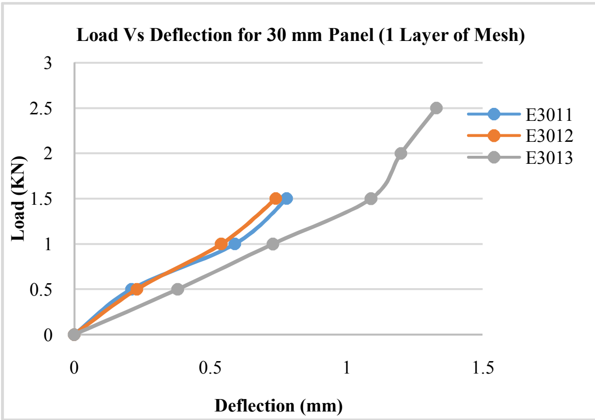
Load (KN)	$E_{20}11$	$E_{20}12$	$E_{20}13$
0.0	0	0	0
0.5	0.51	0.40	0.46
1.0			0.90
1st Cracking Load	0.5	0.52	0.68
Max. Breaking Load	0.62	0.60	1.20
Deflection	0.91	0.87	1.16



Graph I Load-Deflection curves for $E_{20}11$, $E_{20}12$ and $E_{20}13$ panels

Table II Test Results for E_{30} Samples

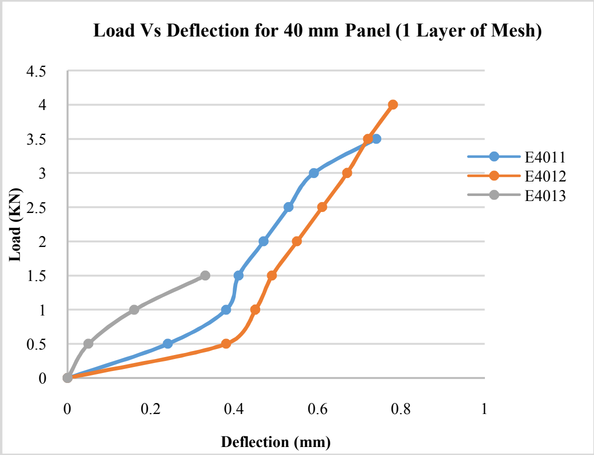
Load (KN)	$E_{30}11$	$E_{30}12$	$E_{30}13$
0.0	0	0	0
0.5	0.21	0.23	0.38
1.0	0.59	0.54	0.73
1.5	0.78	0.74	1.09
2.0			1.20
2.5			1.33
1st Cracking Load	0.88	1.78	2.40
Max. Breaking Load	1.64	1.90	2.80
Deflection	1.12	1.18	1.49



Graph II Load-Deflection curves for $E_{30}11$, $E_{30}12$ and $E_{30}13$ panels

Table III Test Results for E_{40} Samples

Load (KN)	$E_{30}11$	$E_{30}12$	$E_{30}13$
0.0	0	0	0
0.5	0.24	0.38	0.05
1.0	0.38	0.45	0.16
1.5	0.41	0.49	0.33
2.0	0.47	0.55	
2.5	0.53	0.61	
3.0	0.59	0.67	
3.5	0.74	0.72	
4.0		0.78	
1st Cracking Load	3.50	3.50	1.36
Max. Breaking Load	3.58	4.00	1.74
Deflection	0.76	0.78	0.6



Graph III Load-Deflection curves for $E_{40}11$, $E_{40}12$ and $E_{40}13$ panels

Table IV Avg. Flexural strength of ferrocement panels

Specimen	Avg.flexural strength at cracking load(σcr) (N/mm^2)	Avg.flexural strength at ultimate load(σ_{ult}) (N/mm^2)
$E_{20}1$	3.1875	4.5375
$E_{30}1$	4.216667	5.283333
$E_{40}1$	3.91875	4.36875

CONCLUSION

Based upon the experimental test results of the ferrocement panels, the following conclusions can be drawn:

1. The flexural loads at first crack and ultimate loads depend thickness of ferrocement panel, as thickness increases, flexural load at first crack increases. Increasing the thickness also affected the final breaking load for slab panels. Therefore increasing the thickness of ferrocement panels from 20 mm to 40 mm significantly increases the ductility and capability to absorb energy the panels.
2. Increase in thickness of slab panel central deflection at service load on slab panel goes on reducing.
3. The flexural strength of ferrocement panels at first cracking goes on increasing for 30 mm and 40 mm ferrocement panel. The flexural strength of ferrocement panels at first cracking is increased by 32.28% and 22.88% for 30 mm and 40 mm panels respectively as compared with 20 mm panels.
4. The flexural strength of ferrocement panels at breaking load is increased by 16% for 30 mm panels and decreased by 4% for 40 mm panel as compared with 20 mm panels respectively.

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