Flexural Behaviour of Ferro Cement Panels with Different Types of Meshes

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Abstract— The present study describes the results of testing ferrocement panels reinforced with of different types of meshes. The main objective of the study was to investigate the effect of different types of meshes as reinforcement in thin mortar specimen and select the best suitable mesh for further work. Types of meshes were used expanded metal mesh, galvanized woven mesh and welded mesh has a diameter of 1.58 mm. Size of openings are 20x35 mm, 10x10 mm and 15x15 mm. Panels of a size of 560x150x35 mm were reinforced with three layers of wire mesh. Panels were casted with mortar of mix proportion 1:2 and water cement ratio 0.40. The four specimen were tested under four point loading system on universal testing machine after curing period of 7 days and eight specimen after curing period of 28 days. Test results shows that the flexural strength of the specimen with welded mesh exhibits greater flexural strength than other two types of meshes.

Key words: ferrocement, mortar, reinforcing material, deflection, flexural strength

I. INTRODUCTION

The concept of industrialization of the construction technology has emerged as well accepted and preferred option in the field of building construction now a days in order to reduce in-situ construction up to maximum extent. This could be achieved by employing a number of strategies including the application of newly developed cement based composites for structural applications. Cement based composites perform better than conventional plain concrete. The development of new construction materials and technology can partly relieve pressures on the existing building material supply and help to arrest the rise in cost of these materials and also may reduce in-situ construction activities Ferrocement is one of the relatively new Cementitious composite considered as a construction material. 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 or other suitable material such as fiber reinforced plastic and woven fabric [1-3]. Compared to reinforced concrete, ferrocement has homogenous-orthotropic properties in two directions. It exhibits high tensile strength, high modulus of rupture and superior cracking performance. In addition, because of high specific surface of ferrocement meshes, larger bond forces develop with matrix resulting in smaller crack spacing and width. The availability of material in most countries, and no skilled labor required and it being suitable for both prefabrication and self-help construction could lead ferrocement to become one of the most inexpensive and alternative technique for strengthening and rehabilitation of existing and damaged concrete structures. The typical application of ferrocement construction includes water tanks, boats, roofs, silos, pipes, floating marine structures and low cost housing [3-7].

II. FERROCEMENT INGREDIENTS

The ingredients of ferrocement include cement, sand, water and reinforcing mesh.

A. Cement

Ordinary Portland cement is used in making of mortar. The cement should fresh and free from lumps.

B. Aggregates

Normal-weight fine aggregate is the most common aggregate used in ferrocement. The aggregate consists of well graded fine aggregate that passes a 2.34 mm sieve; and since salt-free source is recommended, sand should preferably be selected from river-beds and be free from organic or other deleterious matter and relatively free from silt and clay. Good amount of consistency and compaction is achieved by using a well-graded, rounded, natural sand having a maximum top size about one-third of the small opening in the reinforcing mesh to ensure proper penetration (ACI Committee 549R-97). The moisture content of the aggregate should be considered in the calculation of required water.

C. Water

The mixing water should be fresh, clean, and potable.

D. Reinforcement for Ferrocement

Different types of meshes are available almost in every country in the world. Two important reinforcing parameters are commonly used in characterizing ferrocement and are defined as Volume fraction of reinforcement; it is the total volume of reinforcement per unit volume of ferrocement. Specific surface of the reinforcement, it is the total bonded area of reinforcement per unit volume of composite. The principal types of wire mesh currently being used are hexagonal wire mesh, Welded wire mesh, Woven wire mesh, expanded metal mesh and three dimensional meshes.

1) History of Ferrocement

Joseph Louis Lambot a horticulturist experimented with plant pots, seats and tubs made of meshes and plastered with sand and cement mortar replaced his rotting rowing boat. He called this material as “Ferciment” in a patent which he took in 1852. There was very little application of true ferrocement construction between 1888 &1942 when Pier Luigi Nervi began a series of experiments on ferrocement. He observed that reinforcing concrete with layers of wire mesh produced a material possessing the mechanical characteristics of an approximately homogeneous material capable of resisting high impact. In 1945 Nervi built the 165 ton Motor Yatch "Prune"on a supporting frame of 6.35mm diameter rods spaced 106mm apart with 4 layers of wire mesh on each side of rods with total thickness of 35mm.It weighed 5% less than a comparable wooden hull &cost 40% less at that time. In 1948 Nervi used ferrocement in first public structure the Tutrin Exhibition building, the central hall of the building which spans 91.4m was built of prefabricated elements connected by reinforced concrete arches at the top &bottom of the undulations. In1974 the American Concrete Institute formed committee 549 on ferrocement.ACI Committee 549 first codified the definition of ferrocement in 1980 which was subsequently revised in 1988,1993 and 1997.

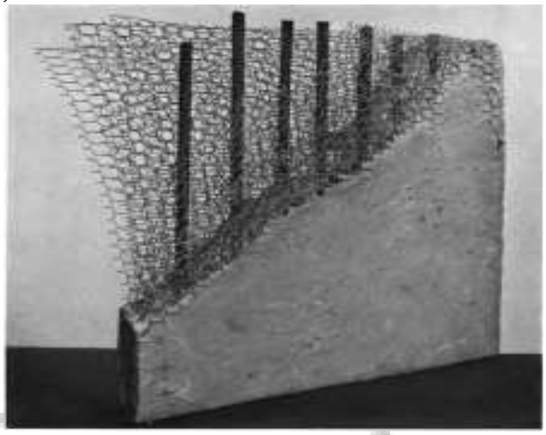

Fig. 1: A Typical Ferrocement Section [1]

III. EXPERIMENTAL PROGRAM

The experimental program was designed to check the flexural behaviour of ferrocement panels which are casted with different type's meshes. For this purpose a total of 9 ferrocement panels of size 560x150x35 mm with three layers of expanded metal mesh, galvanized woven mesh and welded mesh with three in no each were tested in four point loading. The test variables included the different types of meshes having a same diameter but size of opening different. Those panels behaviour were compare with plain mortar panels. Load-defection curves, first crack load, ultimate load and deflection at first crack load and at ultimate load were observed.

A. Materials

Locally available ordinary Portland cement (Grade 53), natural sand passing through 2.36 mm I.S. sieve, ordinary drinking water, three types of meshes which are expanded metal mesh, galvanized woven mesh and welded mesh of 1.58 mm diameter.

B. Mix Proportions

The mix proportion was 1:2 by weight of cement and sand with a water to cement ratio of 0.4. Compressive strength of mortar was 42 MPa.

C. Specimen Preparation and Casting

The mould prepared with water proof plywood sheet and applied two layers of black colour oil paint. The mould was properly oiled before casting. At bottom a layer mortar was applied of thickness 5 mm followed by layer of mesh again followed by layers of mortar. The procedure continues for placing of layers mesh in panel to get desire thickness. Spacing of mesh maintains step by step casting of panels.

Fig. 2: Water Proof plywood Sheet Mould.

The mesh pieces were cut down according to the panel size leaving a cover of 5 mm on both side of mesh.

Fig. 3: Pieces of Meshes.

D. Specimen Testing

After casting of panels they were removed from mould after period of 24 hours. After removal the panels were cured in normal water tank for a period of 7 days and 28 days. The panels were removed from the curing tank after a period 7 days and 28 days. Panels were tested for flexure under universal testing machine with four point loading. The panels were placed on support leaving a space of 50 mm from both the ends. Dial gauge was placed below the panel to record the deflection at each stage of loading. After testing to calculate the flexural strength the panels were loaded under four point loading, load and deflection were noted down. The flexural strength or bending strength was calculated using the bending equation.

Fig. 5: Testing Set-up for Panel.

IV. TEST RESULTS

The results of the four point loading presented in the form of load vs. mid-span deflection curves.

Load (N)	Deflection (mm)			
	PM1	EXM1	GWM1	WM1
0	0	0	0	0
500	0.85	0.7	0.8	0.25
1000	1.35	1.7	1.1	0.84
1500		2.3	1.6	0.99
2000		3.1	1.85	2.05
2500			2	2.82
3000			2.42	3.3
3500			3.1	4.02
4000				4.51
		First Crack Load 10 50 N	First Crack Load 2000 N	First Crack Load 3000 N
	Max. Breaking Load 1050 N	Max. Breaking Load 2200 N	Max .Breaking Load 3800 N	Max .Breaking Load 4300 N

Table 1: Panel Thickness 35 mm, No of mesh layers-3 (7 Days test Results)

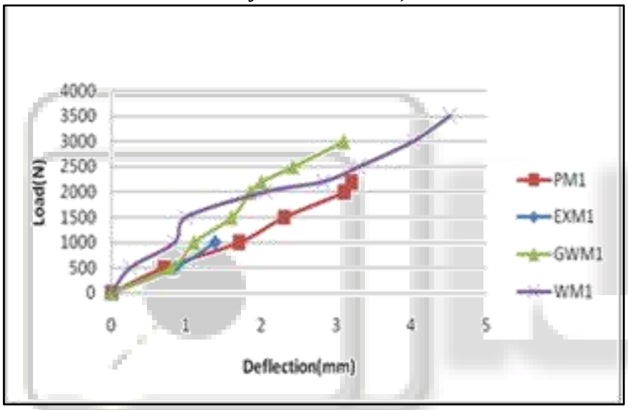

Fig. 6: Graph 1: Load vs. Delection Curves (7 Days test Results)

Load (N)	Deflection (mm)			
	PM2	EXM2	GWM2	WM2
0	0	0	0	0
500	0.13	0.24	0.23	0.7
1000	0.5	0.77	0.78	1.98
1500	1.1	1.15	1.22	2.90
2000		1.90	1.7	4.07
2500		4.1	2.31	6.1
3000			2.9	8.5
3500			3.72	9.57
4000			4.6	12.4
4500			5.4	16.7
5000				
		First Crack Load 2000 N	First Crack Load 3000 N	First Crack Load 3500 N
	Max. Breaking Load 1550 N	Max. Breaking Load 2800 N	Max. Breaking Load 4700 N	Max. Breaking Load 4800 N

Table 2: Panels Thickness 35 mm, No of mesh layers-3 (28 Days test Results)

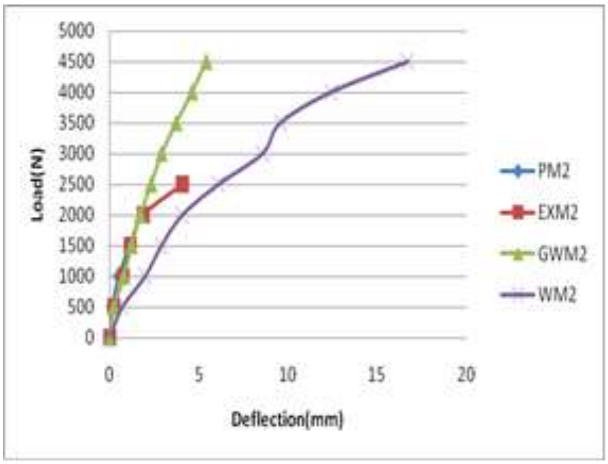

Fig. 7: Graph 2: Load vs. Deflection Curves (28 Days Results)

Load (N)	Deflection (mm)			
	PM3	EXM3	GWM3	WM3
0	0	0	0	0
500	0.3	0.23	0.5	0.18
1000	0.43	0.79	0.93	0.82
1500	1.20	0.88	1.3	1.92
2000		1.73	1.74	2.9
2500		2.6	2.51	3.72
3000			3.38	4.75
3500			5.70	5.70
4000			9.24	6.88
4500				8
5000				11
5500				13.90
		First Crack Load 1500 N	First Crack Load 3500 N	First Crack Load 4000 N
	Max. Breaking 1610 Load N	Max. Breaking Load 2700 N	Max. Breaking Load 4280 N	Max. Breaking Load 5700 N

Table 3: Panels Thickness 35 mm No of mesh Layers-3(28 Days test Results)

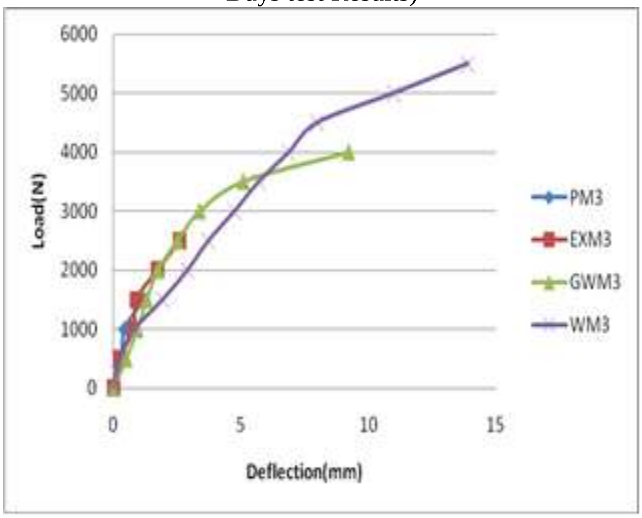

Fig. 8: Graph 3: Load vs. Defection curves (28 Days test Results).

Series No.	No of Layers of Mesh	Flexural Strength at Cracking load f_{cr} (N/mm^2)	Flexural Strength at Ultimate Load f_{ult} (N/mm^2)
PM2	0	No Cracks	3.8
PM3	0	No Cracks	4.03
EXM2	3	5	7
EXM3	3	3.75	6.75
GWM2	3	7.51	11.26
GWM3	3	8.76	10.71
WM2	3	8.76	12.01
WM3	3	10.01	14.26

Table 4: Flexural Strength at Cracking and Ultimate loads for tested Panels. (28 Days test Results)

V. CONCLUSION

Based on the experimental results the following conclusion can be made

1) The flexural loads at first crack load and ultimate loads depend on the types of reinforcing mesh used in ferrocement panels.
2) Substantial increase in flexural strength ferrocement panels reinforced with weld mesh as compare to expanded metal mesh, galvanized woven mesh and plain cement mortar panels.
3) From the above results conclusion can be made that panels with weld mesh has greater tendency to take load than the other two types of mesh.
4) Weld mesh as reinforcement used for the ferrocement panels give good results and this type of mesh used for further experimental work.

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