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RESEARCH ARTICLE

Low Cost Ferrocement Composite Roof/Floor System

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Abstract

This paper, is a part of continuous research, aims to examine the suitability of cast-in-place Ferro cement composite slab as a roof/floor system. This continuous study is mainly based on experimentation. Ferro cement is a combination of cement/sand (1:2.5) mortar, having a compressive strength higher than 30 N/mm², and expanded metal with R6mm bars. Can be formed in any shape not more than 50 mm thickness. Two panels each consist of a 50 mm slab casted over corrugated zinc sheet of 1.0m width and 4.5 m length supported by two rectangle steel pipes, along the long side and spaced at 50 cm. The pipes were connected to the panels by self – drill screws and shear keys. Steel pipes were (120 mm x 50 mm x 1.8 mm) and (100 mm x 50 mm x 1.8 mm) for each panel A and B respectively. As cast-in-place technique, the whole floor will be casted in a single day, whereas, precast panels require forms and handling effort. Panels were tested using 50 kg cement bags as a uniform distributed load. The experimental results show that panels have enough strength and can be used within the allowable service deflection limit, as a roof/floor system.

Keywords: Ferro cement floor, Roof slab system, Composite beam, Composite floor.

1.Introduction

Ferrocement is a thin slab of cement–sand mortar reinforced by small size wire mesh, tied on frame of steel bars, which possesses unique characteristics of high strength, durability and can take any shape and form [1, 2]. Joseph-Louis from France invented Ferrocement in 1852; and used it in boat construction. In 1947, Nervi built store, house and swimming pool from Ferrocement at the Italian Naval Academy, then it has attained worldwide popularity in buildings, in China, India, Cuba, Sudan ...etc.

Ferrocement half-cylindrical roofing systems were adopted by E.A. Adam, in ElhajYousef region in Sudan, to construct Holem schools and Police Housing [3].

1.1. Aims and Objective

The aim of this paper is to study the carrying capacity of Light weight composite Ferro cement panel roof/floor system as an alternative to the Reinforced concrete slabs/jack arch systems through experimental work validation.

2.Material Characterizations

Ordinary Portland cement with Compressive strength after 28 days curing = 44.83 N/mm² is used in panels mortar matrix according to BS812-1996. Fine aggregate (sand) used is from Kanjar barrow area, North Bahri, with properties presented in Table 1.

Table 1. Sand Properties

SIEVE Size (mm)	RETAI NED (gm)	RETAIN ED (%)	PASS (%)	STAND ARD (%)
2.36	26	5.269	94.732	100-80
1.18	125.5	25.431	74.569	85-50
0.6	283.5	57.47	42.53	60-25
0.3	394	79.838	20.162	30-10
0.15	458.5	92.91	7.09	10-2
>.15	493.5	1		

Potable Water was used for mixing and as well as for curing. The main bars used in the present work are mild steel 6 mm diameter steel placed on Zinc sheet (as permanent frame) riveted to the supporting pipes. Expanded metal with hexagonal opening of size 10 mm and thickness of 1mm was used.

3.Experimental Works

3.1. Test Panels

In this study two Ferro cement panels A, B were prepared have the same form but differ in steel pipes (RHS) sizes as in (Table 2) and

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shown in Figure 1 and Figure 2.

Figure 1. Ferro cement Panel Dimensions

Figure 2. Panel Reinforcement Details

Table 2. Properties of Rectangular Hollow Pipe Sections Sand Properties

Panel	RHS properties	b (mm)	h (mm)	t (mm)
Panel A		60	120	1.8
Panel B		50	100	1.8

3.2. Geometrical form and Reinforcements Details

Two hollow rectangular steel Pipes, each of length 4.8 m, spaced at 50 cm were linked by three pipes of the same size by welded at Centre and at 2.25 from Centre in both sides. Corrugated Zinc sheets of length 1m are fixed over the hollow Pipe Frame with it is ribs perpendicular to the long span of Pipe Frame. Sheets were riveted with the Pipe frame by self-drill screws positioned at the Centre of sheets ribs. Expanded metal was laid over the zinc sheeting then four R6mm bars fixed to it by wires, as shown in Figure 3 and Figure 4.

Figure 3. Panel Pipe Framing

Figure 4. Expanded Metal & 6mm Bars Reinforcement Placement

3.3 Mix Proportion

The cement-sand mortar's mix was prepared by weight using the following mix in Table 3.

Table 3. Mix Proportion

Cement/Sand	Water/Cement
1:2.5	0.5

The panels were vibrated during casting by vibration table machine, as shown in Figure 5.

Figure 5. Compaction by Vibration Table Machine

3.4 Test Procedure

Two heavy steel I-sections spaced 4.5 m from each other, were placed as simply support. The panels were positioned over the supports, and a Dial-Gauge were adjusted under it centre and connected to the centred pipe that linked between the longitudinal pipes, as shown in Figure 6 and Figure 7. The panels were tested by applying a gradual uniformly distributed load from Layers of cement bags. Deflection was recorded with each layer placement, up to failure of excessive deflection/cracks.

Figure 6. Positioning of Panel by Crane

Figure 7. Setting of Dial Gauge

4. Results and Discussion

4.1. Panel Carrying Capacity's Tests result

The behavior of panels for every level of load increment were tabulated as in Table 4. and shown in Figures 8 to 11.

Table 4. Load-Deflection Results

No. of Cement bags	kN/m	Panel (1) 60x120x1.8 mm Deflection mm	Panel (2) 50x100x1.8 mm Deflection mm
0	0	0	0
8	0.872	3.80	5.95
16	1.744	7.95	11.8
24	2.616	11.89	20.3
32	3.488	17.52	30.5
40	4.36	24.4	43.33
48	5.232	36.55

Figure 8. Panel 1 during Loading

Figure 9. Panel 1 Full Loading

Figure 10. Panel 2 During Loading

Figure 11. Panel 2 Full Loading

4.2. Discussions

4.2.1. Carrying Capacity

Panels Carrying capacity increase as the size of the hollow rectangular steel pipe increase.

The 28-day Compressive strength of the two Panels were 30 and 38.6 N/mm² as in Table 5.

Table 5. Panels Compressive Strength

Panel	28 days cube strength N/mm ²
1	30
2	38.6

Total design load of 1 kN/m² finishes and 1.5 kN/m² Live load is equal to 2.5 kN/m can be carried safely by the two panels within:

11 mm deflection limit for Panel 1.

19 mm deflection limit for Panel 2.

4.2.2. Cracks Pattern

For both panels the appearance of cracks was approximately noticed from the third layer of cements bags. Cracking were noticed during loading and it is more in panel 1 than panel 2.

Cracks pattern appeared to be perpendicular to span of beams (hollow pipes) in both panels, as shown in Figure 12 and 13.

Figure 12. Panel 1 Cracks Pattern

Figure 13. Panel 2 Cracks Pattern

4.2.3. Load/deflection curve:

Average of deflection increment with Load is more in panel 2 than panel 1. Panels Deflection decrease as the section of hollow rectangular steel pipe increase.

Curves Figures as in Figure 14 represents that panels had shown similar responses. Panels showed elastic behavior.

Since the beam is carrying brittle finish thus according to BS5950[10] the standard limit of deflection is $L/360 = 4500/360 = 12.5$ mm but not more than 20 mm. Panel 1 and Panel 2 were reached to the standard deflection limit at 2.7 kN/m and 1.8 kN/m respectively.

At 30 mm deflection limit: Panel 1 can carry more than 19.62 kN Panel 2 can carry 15.696 kN.

Figure 14: Panels Load -Deflection Curves

5. Conclusions

This paper determined the carrying capacity of composite Ferrocement floor system through experimental investigation. Composite system of hollow rectangular steel pipes and Ferro cement slab were used in the experiments. The systems were tested under uniformly distributed load of cement bags and results were recorded.

The results showed that, the Ferrocement floor panels are lighter than conventional reinforced concrete system, and with the use of Zinc sheets, it is easy to be cast in situ and its strength gained within 3-4 days and can carry safely the finishes and live load within service deflection limits.

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