LOW-COST FERROCEMENT COMPOSITE ROOF/FLOOR SYSTEM

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مُسْـتَخْلَـص

هذه الورقة العلمية هي جزء من بحث مستمر , يهدف الي إظهار جدوى إستخدام مادة الفيروسمنت المصبوبة في الموقع لنظام سقف/أرضيات المباني. وتعتمد الدراسة المستمرة أساسا علي التجريب.الفيروسمنت هو مزيج من الأسمنت /الرمال (1:2.5) مونة أسمنتية ،ذات قوة ضغط أعلي من 30N/mm² ، وشبكة إكسباندا مع اسياخ حديد بقطر 6mm، يمكن إستخدامها في أي شكل بسمك لا يزيد عن 50mm. وحدتين فيروسمنت ،كل تتكون من لوح سمك 50mm مصبوب علي ألواح زنك معرج بعرض 1.0 m وطول 4.5m مدعومة بماسورتين حديد علي طول اللوح والمسافة بينهما 50cm.المواسير تم وصلها باللوح بواسطة مسامير ذاتية الثقب وأوتاد قص .مواسير الحديد بمقاسات (120mmx60mmx1.8mm) و (100mmx50mmx1.8mm) لكل من اللوح A وB علي التوالي.لتقنية الصب في الموقع ،كل السقفة تصب خلال يوم واحد ،في حين أن اللوحات السابقة الصب تحتاج لي جهد للنقل والتشكيل. تم إختبار الوحدات اللوحية بإستخدام أكياس الأسمنت عبوة 50kg كحمولة موزعة .أظهرت نتائج التجربة أن اللوحات لديها قوة كافية ويمكن إستخدامها كنظام سقف/أرضى في حدود الإنحراف التشغيلي المسموح به.

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. The 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 utilized in any form and shape not more than 50mm thick. Two panels each consist of a 50mm slab casted over corrugated zinc sheet of 1.0m width and 4.5m length supported by central two rectangle steel pipes spaced 50cm along the long side. The pipes were connected to the panels by self –drill screws and shear keys. Steel pipes were (120mmx50mmx1.8mm) and (100mmx50mmx1.8mm) for each panel A and B respectively. For 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 50kg 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 laminate of cement –sand mortar reinforced by small size galvanized wire mesh, tied on skeletal frame of steel bars, which possesses unique characteristics of high strength, durability and can take any shape and form [1,2]. It was invented by Joseph-Louis Lambot of France in 1852; applied it in boat construction. In 1947, Nervi built a Ferro cement store house and swimming pool 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 Elhaj Yousef, 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 type N42.5, having Compressive strength after 28 days curing = 44.83N/mm²., is used in the panels mortar matrix according to BS812-1996.Fine aggregate used is from Kanjar barrow area, NorthBahri, with prosperities presented in Table 1.

Table 1: Sand Properties

SIEVE (mm)	RETAINED (gm)	RETAINED (%)	PASS (%)	STANDARD (%)
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 skeletal bars used in the present work are R6 mm diameter steel placed above Zinc sheet (as dead shuttering) riveted to the supporting pipes. Expanded metal with hexagonal opening of size 10mm and thickness of 1mm was used.

3 Experimental Works

3.1 Test Panels

In this study two Ferrocement panels A, B were prepared with the same form and shape, but different steel pipes (RHS) sizes (Table 2) as shown in Figure 1 and Figure 2.

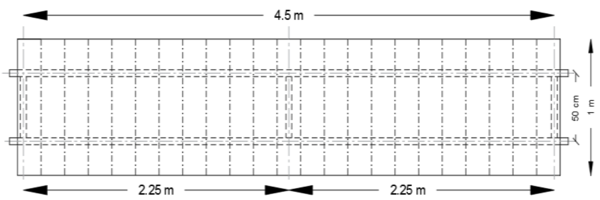

Figure 1: Ferro cement Panel Dimensions

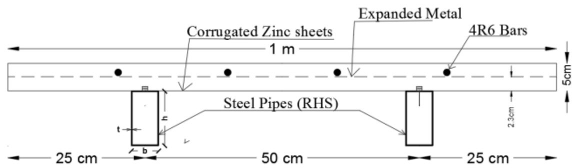

Figure 2: Panel Reinforcement Details

Table 2: Properties of Rectangular Hollow Pipe Sections

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

3.2 Geometry and Reinforcement Details

Two hollow rectangular steel Pipes, each of length 4.8m, spaced at 50cm 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.

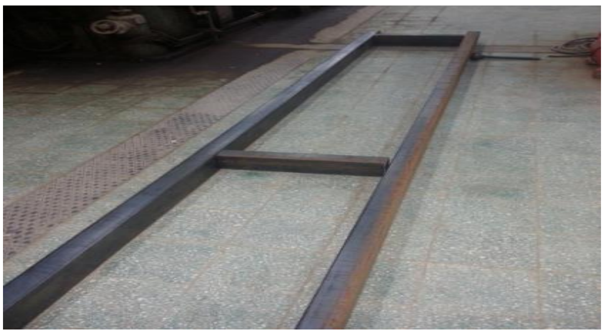

Figure3: Panel Pipe Framing

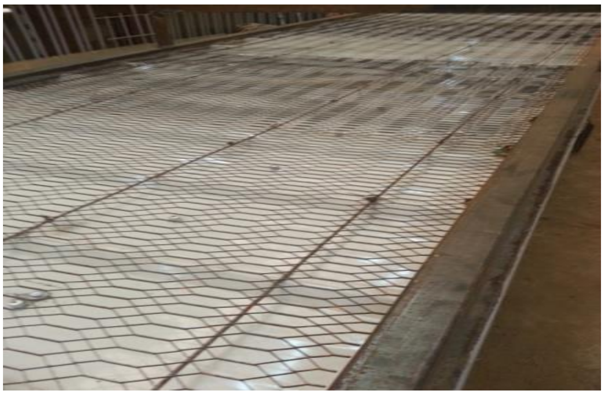

Figure4: Expanded Metal & 4R6 Bars Reinforcement Placement

3.3 Mix Proportion

The cement-sand mortar 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, as shown in Figure 5.

Figure 5: Compaction by Vibration Table

3.4 Test Procedure

Two heavy steel I section, placed at 4.5 c/c, were used as a line simply supports. The panels were positioned over the support and a dial gauge were fixed under it centre and connected to the hollow pipe linked between the beams, as shown in Figure 6 and Figure 7. The panels were tested by applying a gradual uniformly distributed load of Layers of cement bags. Deflection was taken with each layer placement up to failure or excessive deflection/cracks.

Figure 6: Handel of Panel by Crane

Figure 7: Setting of Dial Gauge

4 Results and Discussion

4.1 Panels Carrying Capacity Test result:

The behavior of panels for every level of load increment were tabulated 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	

4.2 Discussions:

4.2.1 Carrying Capacity:

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

The 28-day Compressive strength of the two

Panels was 30 and 38.6 N/mm2 as in Table 5.

Table 5: Panels Compressive Strength

Panel	28 days cube strength N/mm²
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:

11mm deflection limit for Panel 1.

19mm deflection limit for Panel 2.

Figure 8: Panel 1 during Loading

Figure 9: Panel 1 Full Loading

Figure 10: Panel 2 During Loading

Figure 11: Panel 2 Full Loading

4.2.2: Cracks Pattern:

For both panels the appearance of cracks was approximately noticed from the third layer of cements bags. 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 defection increment with Load is more in panel 2 than panel 1. Curves Figures as in Figure 14 represents that panels had shown similar responses.

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

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

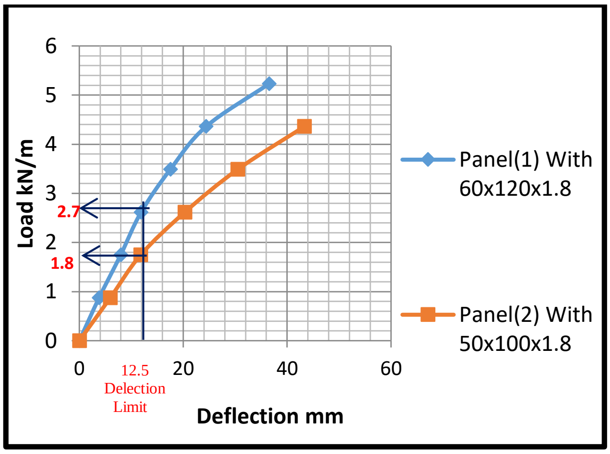

Figure 14: Panels Load –Deflection Curves

5 Conclusions

This paper determined the carrying capacity of composite Ferrocement floor through experimental investigation. Composite section 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 Ferrocement floor panels are lighter than concrete slab, and with the use of Zinc sheets it is easy to be cast in situ and it strength gained within 3-4 days. The panels can carry safely the finishes and live load within service deflection limits.

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