

Structural behaviour of ferrocement–brick composite floor slab panel

Waleed A. Thanoon^{a,*}, Yavuz Yardim^b, M.S. Jaafar^c, J. Noorzaei^d

^a Professor & Dean, College of Engineering and Architecture, University of Nizwa, Nizwa, Oman

^b Assistant Professor, Engineering Faculty, Epoka University, Albania

^c Professor & Dean, Engineering Faculty, University Putra Malaysia, Malaysia

^d Associate Professor, Engineering Faculty, University Putra Malaysia, Malaysia

ARTICLE INFO

Article history:

Received 21 May 2007

Received in revised form 21 March 2010

Accepted 1 April 2010

Available online 14 May 2010

Keywords:

Ferrocement

Composite slab

Brick layout

Steel truss shear connector

ABSTRACT

This study introduces a semi-fabricated system for the construction of floor slab. The slab panel consists of two layers joined together using truss type shear connectors. The first layer is a precast ferrocement layer which acts initially as a formwork, while the second layer consists of bricks and mortar. Continuous truss shear connectors are used to connect the two layers. The paper experimentally investigates the structural response of ferrocement–brick composite panel under flexural load. Four full scale specimens were cast and tested under two-line loads. The study highlights the effect of shear connectors and brick layout on the overall structural response of the slab. The results in terms of load–deflection, crack pattern, strain distribution and failure loads indicate that the response of the composite slab to the flexural loading is satisfactory and can be used as a floor slab in construction sector.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

Prefabricated floor is used in the construction sector in many parts of the world. It is an alternative system used to overcome the formwork problems (cost and delay in construction) in addition to getting better quality control. It was found, however, that the prefabricated elements made of reinforced concrete are very heavy and difficult to transport and construct. In addition, concrete provides low thermal insulation quality, which is desired for living quarters and shelters. Jointing connectivity is another problem observed in precast construction, which leads to somehow, a less integrated structure. To reduce these deficiencies, a large number of precast systems have recently been developed. Pessiki et al. [1] summarized the use of 19 different precast structural floor systems that are suitable for office building construction in different parts of the world. Thin ferrocement panels were used in floor construction for low cost housing [2,3] due to its low cost and good structural performance. The introduction of insulating sandwich panels increased the attractiveness of this type of construction. The panels consist of thin layers of relatively higher strength material sandwiching a thick core, of normally much weaker and lower density material [4–6]. However, the high manufacturing and construction costs limit the use of precast sandwich panels in construction. The profiled sheeting–cement board composite is another recent development in the floor slab system [7,8]. The system consists of profiled sheeting attached to a top layer of dry

board by simple mechanical connectors. Lightweight concrete with a density of 1000 kg/m³ was used as an infill material to act as a sound insulator for the floor. However, one of the limitations of this system is its low stiffness which results in a large deflection and development of cracks in the finishing elements connected to the slab.

Half-slab construction technique is another development in the construction of floor slab [9,10]. The techniques employs reinforced precast floor panel that serve as permanent formwork which is composite with cast in situ concrete. Steel lattice trusses project from the top of the precast unit were used to connect the two layers and provides the unit with stiffness during erection. Again the heavy weight of the full slab and their low thermal efficiency are some of the disadvantages of the system.

To develop a new floor slab system to overcome the shortcoming in the in situ concrete floor slab and existing precast floor systems is a challenging task for many researchers. As a summary, the main shortcomings in the existing systems could be one or more of the followings:

- Long construction time.
- Heavy weight.
- Dependency on heavy equipment on job site.
- Bad thermal and sound barrier.
- Wastage of material
- Dependency on formwork.
- Does not ensure structural integrity.
- Jointing problems.
- High cost.

* Corresponding author. Tel.: +968 2544 6401; fax: +968 2544 6245.
E-mail address: w.thanone@unizwa.edu.om (W.A. Thanoon).

This study introduces a semi-precast floor slab system; ferrocement–brick composite slab to address some of the above listed shortcomings in existing systems. The new system consists of a bottom ferrocement skin, brick masonry and in situ mortar ribs. The ferrocement layer is the precast part of the composite slab, which consists of a wire mesh and steel reinforcement, required to resist the tensile stresses. The thickness and reinforcement of this layer will depend mainly on the span of the slab. The brick layer and the in situ ribs provide the necessary resistance to the compressive forces developed due to bending. The two layers are interconnected using truss type shear connectors (see Fig. 1).

The advantages of this system, amongst others, are its relatively lighter weight compared to R.C which will reduce the load transferred to the beams/walls. The masonry bricks act as light (especially voided brick), natural, cheap effective insulation material and at the same time resisting partially the compression forces developed due to bending of the composite. On site, the construction of the composite slab does not require heavy equipments to handle the ferrocement layer.

Furthermore, the construction does not need any formwork since the bottom layer of ferrocement is a precast unit that can be easily fixed in position, using simple crane, to provide a platform that acts as a formwork for the brick layer and the in situ concrete ribs. However, laying the brick might be labour intensive job especially in countries where the cost of labour is high. Alternatively, the masonry brick may be laid during casting the ferrocement layer in the factory to reduce the need for intensive labour.

The cold joint problem usually observed in precast construction could be eliminated in this system. The floor slab units together with the supporting beams might be integrated during casting of the in situ mortar ribs.

This experimental study is limited to investigate the structural performance of one way ferrocement–brick composite slab subjected to two-lines loading. The study highlights the effects of bricks layout and shear connectors layout on its overall structural response in terms of load–deflection characteristic, ductility, strain distribution, composite action and failure load.

2. Test program

Four full scale one way (termed as S1 through S4) simply supported (using steel roller at one end and a square steel rod at the other end of the specimen) slab ferrocement–brick composite specimens 3 m long and 1 m wide were cast and tested under two-line loading. The specimens differ in brick layout and number of shear connectors. The shear connector used is a continuous steel truss made of 5 mm diameter mild steel zigzagged at 45° angles. For the slab S1, S2, S3 and S4, the numbers of bricks used in each slab are 60, 93, 88 and 108 respectively. The composite slab details and shear connector layout are shown in Fig. 2, while the arrangements of bricks for each slab are shown in Fig. 3. In all

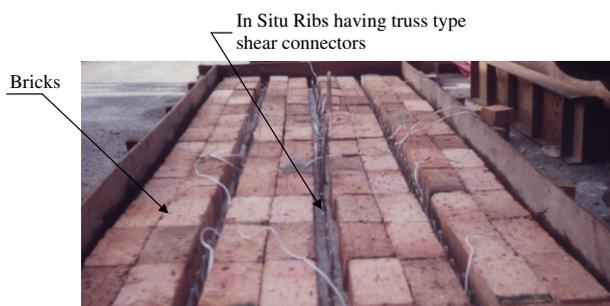


Fig. 1. Ferrocement–brick composite slab.

the specimens, the thickness of ferrocement layer is fixed to be 60 mm reinforced with two layers of 1.2 mm diameter wire mesh of 12.7 × 12.7 mm square opening and 10 mm diameter steel reinforcement as shown in Fig. 2. The brick layer is 65 mm thick (brick size 215 × 90 × 65). All the specimens were designed considering full composite action between the ferrocement layer and the layer of brick–concrete ribs. The surface areas and volumes of the bricks with respect to total surface area and total volume of the specimen are presented in Table 1 along with the number of trusses used as shear connectors and rib details in both longitudinal and transverse directions.

For both ferrocement layer and in situ mortar ribs, Ordinary Portland Cement and natural sand were used in a ratio of 1:3 with water/cement ratio of 0.5. The 28-day average cube strength of this mix was 30 MPa. The tensile strength of the wire mesh and steel reinforcement tested using Universal Test Machine was found to be 300 MPa and 415 MPa respectively. Initially, the ferrocement layer is cast after preparing the wire mesh, steel reinforcement and shear trusses. Next the bricks are laid on the top of ferrocement layer according to a specified layout for each specimen as shown in Fig. 4.

All specimens were tested as simply supported slabs over 3 m span with two-concentrated line load applied at the middle-third of the slab. Typical set-up of two-line load test is shown in Fig. 5. The loads were applied gradually using a hydraulic jack of 100 kN capacity. At every increment of the load, the reading of dial gauges and strain gauges were recorded until failure of the slab specimen. A number of demec points were fixed along the depth on the sides to measure the strain variation with load. Deflection under the middle-third was continuously monitored using both dial gauges and displacement transducers (LVDT). The locations of the cracks were marked with the progress of the applied load.

3. Structural response

3.1. Deformation and ductility characteristics

The load–deflection characteristics for all slab specimens are shown in Fig. 6. In general, the deformation responses of all the composite slabs are comparable. All the specimens behave in an elastic manner before cracking after which the stiffness of the specimen reduces and the slope of the load–deflection curves decrease. This gradual loss of stiffness with increasing load is due to cracking of concrete in ferrocement layer, cracking of the mortar in the connector embedment regions and yielding of steel reinforcement. The slab specimens S1 and S2 with two longitudinal ribs (dual shear connectors) show different deformation responses after cracking. The slab with discontinuous brick layout “S1” shows 70% higher maximum deflection compared to the slab with continuous brick layout “S2”. This high percentage increase in ultimate deflection is associated with 10% difference in ultimate load between both specimens.

Table 2 summarizes the cracking load of ferrocement, yielding load of main steel reinforcement, ultimate load at failure and deflection. In addition, the ductility of each specimen (defined here as the ratio of deflection at ultimate load to the deflection at yielding load) is calculated and presented in the same table. In general, all the tested specimens show ductility higher than 2.0, the specimens with continuous brick layout show less ductile behaviour compared with the specimens with discontinuous layout of bricks. This might be due to the gradual loss of bond between the bricks and surrounding mortar, which will take longer time in case of discontinuous layout as the mortar surrounds all the sides of the bricks compared to two sides of the bricks in the continuous brick layout. The slab specimen S3 with discontinuous brick layout (longitudinal

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات