BENDING BEHAVIOR OF COMPOSITE FERRO-CEMENT SLABS IN COLD FORMED STEEL FLOORS

By
Adham Elsayed Zakaria Tonsy Mohamed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the Requirements for the degree of
MASTER OF SCIENCE
In
Structural Engineering

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Title of Thesis:

Bending behavior of composite Ferro-cement slabs in cold formed steel floors

Keywords:

Ferro-cement slabs, shear connector, CFS section, and wire mesh

Summary:

This study investigates the structural bending behavior of continuously supported composite Ferro-cement slabs, in which a Ferro-cement slab is connected together with cold-formed steel (CFS) beam where shear forces are transmitted between the beam and slab through shear connectors or studs. This research is based on Experimental works involved full-scale testing of laboratory tests consisted of a total of nine full-scale continuously supported composite Ferro-cement slabs with different parameters and tested to fracture. The main variables considered in the study are thickness of the Ferro-cement slab and different spacing between bolts.

DISCLAIMER

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section

Name: Adham Elsayed Zakaria Tonsy Mohamed Date: 19/11/2018

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ABSTRACT

This study investigates the structural bending behavior of continuously supported composite Ferro-cement slabs, in which a Ferro-cement slab is connected together with cold-formed steel (CFS) beam by means of shear connectors. This system, called a Precast Cold-Formed Steel-Ferro-cement Composite Slab System, is designed to produce the composite action between the CFS structure and Ferro-cement slab where shear forces are transmitted between the beam and slab through shear connectors or studs. Ferro-cement slabs can be defined as a thin reinforced concrete structure in which a brittle mortar is reinforced with layers of thin wire mesh, uniformly dispersed throughout the matrix of the composite section. This research is based on Experimental works involved full-scale testing of laboratory tests consisted of a total of nine full-scale continuously supported composite Ferro-cement slabs with different parameters and tested to fracture. One type of shear connectors (bolts) was tested and one layer of wire mesh in Ferro-cement cold formed was proposed. The main variables considered in the study are thickness (30mm, 40mm) of the Ferro-cement slab and different spacing between bolts (450mm, 150mm).Uniform load bending system was used to test the specimens. The results confirmed that increasing the thickness of Ferro-cement slab has not significantly increased the load capacity of the composite slab. However, the increase in slab thickness has delayed the formation of cracks at an early stage. Also, using spacing between bolts (150 mm) has increased the capacity load of the fully composite section by almost one third the capacity load of the non-composite section (Spacing 450 mm).

Chapter One: Introduction

1.1 General Appraisal:

Using composite slabs, to improve the stiffness and the load capacity of the slab, become more popular in the building industry. The composite slab has resulted in great savings in the weight of steel structure and reduction in beam depth. For more economical section, cold-formed steel sections interact with the Ferro-cement slab through shear connectors. (Deierlein, 1988; Viestetet al., 1997)

The advantages of composite construction have been widely spread due to the use of Ferro-cement as a pre-cast composite slab. Composite action depends on interactive behavior between steel section and concrete components designed together to be more efficient in resisting the applied loads.

The interaction between steel and concrete in the composite structure was as following; the upper compressive force was carried by the concrete slab and the lower tensile force was carried through the tensile resistance of the steel section. The interaction between the concrete slab and the steel beam is provided through shear studs to resist the shear flow at the interface of the two materials.

Welding of shear studs is not applicable due to the relatively small thickness of the cold formed sections (Hanaor, 2008); so, the shear connection between CFS and concrete must be investigated and need more research.

The manufacturing of cold formed steel section is carried out at room temperature, through rolling up a steel sheet of thickness from 1.5 mm to 4 mm. The use of CFS section in the building industry started in the 1850s in both the United States of America (USA) and Great Britain (UK). The CFS structural sections have many advantages than hot-rolled sections, such as small thickness, lightness, ease of prefabrication, fast erection, and installation.

One of the established commercial applications between CFS and concrete is the composite slab system, where a concrete layer is placed on top of CFS section. However, the structural use of CFS sections began in the mid of 20th century especially for industrial and commercial buildings (Hancock et al., 2001). The typical sections widely used as purlins and truss members are "Z" and "lipped C" sections (Figure 1.1).

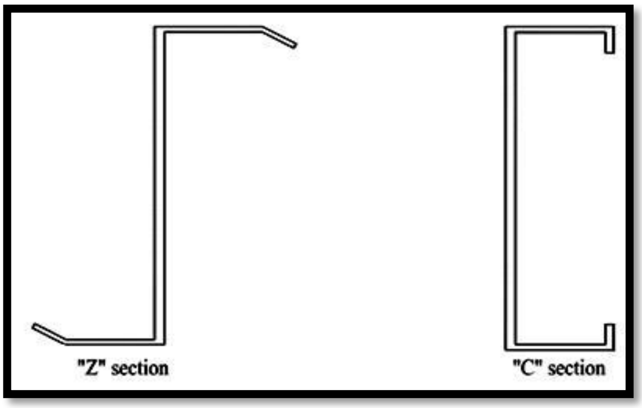

Figure 1-1 Typical CFS sections

Composite construction of CFS sections and concrete began in Europe since 1940 and was mainly used for roof systems, where a metal deck made from CFS was used to act compositely with concrete (Sabnis, 1979).

Ferro-cement slabs can be defined as a thin reinforced concrete structure in which a brittle mortar is reinforced with layers of thin wire mesh, uniformly dispersed throughout the matrix of the composite section (Naaman, 2000). Ferro-cement slabs have taken a significant place between the construction elements for its mechanical and durability properties which recommend it the most suitable system for lightweight structures. Ferro-cement slabs consider being an economic and suitable alternative material for roofing; however flat or corrugated roofing system is quite popular.

This study investigated the structural behavior of composite slab system with CFS as beam and Ferro-cement as slab. This type of system could solve the problem of a low rupture bending capacity of the Ferro-cement slab. The proposed composite slab system improves the rupture bending capacity and reduces the deflection due to the composite action and also speeds up the construction time as the proposed Ferro-cement slab acts as permanent formwork.

1.2 Problem Statement

Over the years, Ferro-cement slabs applications have widely increased due to its mechanical and durability properties such as strength, toughness, lightness, and ductility. The wide spread of Ferro-cement slab in the construction industry is due to relatively low cost, weight and the ease of the production.

Although CFS slabs system is considered one of the most important construction element as a sustainable structures in the developed countries have been recognized as an important contributor to sustainable structures in the developed countries (Yu et al., 2005), its application is limited to roofing systems and non-structural applications (Shaari & Ismail, 2003). This can be attributed to the small thickness of its cross-section that makes it easily subjected to torsion failure, distortional, lateral torsional, lateral distortional and local buckling

Pre- fabricated Ferro-cement slabs is widely used in the developed countries as mention before. It considered one of the best alternatives in the construction industry to overcome the high cost of the other building systems, and ease of erection which reduce the time of the construction period and to get better quality control.

In this study, a type of composite slab comprised of CFS section with Ferro-cement called Precast Cold–Formed Steel-Ferro-cement Composite slab System is proposed to reduce the weight as well as to improve the strength of the composite system. One of the main advantages of this system is its light weight compared to normal reinforced concrete slab which results in the reduction of loads transmitted to supported elements.