EXPERIMENTAL INVESTIGATION ON LIGHTWEIGHT COMPOSITE SLAB SYSTEM WITH HOLLOW BOX BEAM FOR FLOOD RESISTANT

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To my beloved mother and father

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ABSTRACT

Composite slabs are gaining wide acceptance in many countries as they are faster, lighter and economical in construction buildings. The ultimate behaviour of steel-concrete Lightweight composite slab system with hollow box beamis experimentally investigated in this paper. The strength of composite slabs system relies on the bonding action between the concrete and the steel deck, the shear connections and the cross sectional resistance of steel beam. However, structural behaviour of composite slab is complex phenomenon and therefore experimental study is often conducted to establish the strength of the structure under ultimate load capacity. The main objective of this study is to determine the structural behaviour of lightweight composite slab system with hollow box beam, compare the analysis and design method according to Eurocode 4. Total of two specimens are examined in order to obtain failure mechanism of the composite structure under full load capacity. A new design approach of composite slab for roofing system is proposed in this study and compared to experimental result. The comparison shows good agreement between experiment and theoretical results.

ABSTRAK

Papak komposit semakin mendapatkan penerimaan di banyak negara kerana cara pembinna ini lebih cepat, ringan dan menjimatkan masa pembinaan bangunan. Sifat-sifat struktur sistem papap komposit skala penuh diuji dalam penyelidikan ini. Sifat-sifat sistem papak komposit bergantung kepada ikatan antara konkrit dan plat keluli, sambungan ricih dan rintangan keratan rentas rasuk keluli. Walau bagaimanapun, sifat-sifat struktur papak komposit adalah fenomena kompleks dan oleh itu kajian eksperimen sering dijalankan untuk mengaji kekuatan struktur di bawah kapasiti beban muktamad. Objektif utama kajian ini adalah untuk menentukan sifat-sifat struktur sistem papak komposit ringan, membandingkan kaedah analisis dan reka bentuk berdasarkan Eurocode 4. Dua ujian berskala penuh dikaji dalam penyelidikan ini untuk mendapatkan mekanisme kegagalan struktur komposit di bawah kapasiti beban penuh. Kaedah reka bentuk baru papak dibandingkan dengan keputusan ujian makmal dan menunjukkan persetujuan yang baik.

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LIST OF SYMBOLS

M_{rd}	-	The bending resistance per unit width
$N_{c,f}$	-	Compressive force in the concrete
N_p	-	Tensilte force in the profiled steel sheeting/steel deck
A_{pe}	-	The effective area of the profiled steel sheeting, per unit width of slab
Z	-	The lever arm
h_s	-	The depth of the slab
e	-	The height of the centroidal axis of the profiled steel sheeting above the underside of the sheet
b	-	The unit width of slab
e_p	-	The distance from the underside of the profiled steel sheeting to the plastic neutral axis of the profile
M_{pa}	-	The bending resistance of the profiled steel sheeting per unit width of slab
L_x	-	The distance to the cross section considered from the nearest support
R_{Ed}	-	The support reaction
d_p	-	The distance between the centroid axis of the profiled steel sheeting and the extreme fibre of the composite slab in compression
m,k	-	Design values of empirical factors
L_s	-	The shear span
v_{Ed}	-	is the design longitudinal shear stress in the concrete slab
f_{yd}	-	is the design yield strength of the reinforcing mesh
h_f	-	is taken as the depth of concrete above the profile sheeting, equals to h_c

θ_f	-	given in BS EN 1992-1-1 as the angle for compression struts.
f_{ck}	-	Characteristic cylinder strength of the concrete
A_{sl}	-	Area of the tensile reinforcement
b_w	-	Smallest width of the cross-section in the tensile area
d	-	Effective depth of the section
N_{ed}	-	Axial force in the cross section due to loading or prestressing
Ac	-	Area of concrete cross section

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The conventional methods of building construction in Malaysia are normally prompt to the design of RC structures, precast concrete, timber structures etc. In order to overcome the weakness of tensile stress in reinforced concrete, steel reinforcement bars, reinforcement grid or plates are added. Composite structures have been implemented as one of the innovative concepts to replace the reinforced concrete design. A composite slab with profiled steel decking design is one of the simple, faster, lighter and economical constructions in steel-framed building systems. The system is well accepted by the construction industry due to many advantages over other types of floor system (Andrade 2004; Makelainen and Sum 1999). A composite slab system normally consists of normal weight or lightweight reinforced concrete placed permanently over profile cold-formed steel deck in which acts as permanent formwork during concrete casting and tensile reinforcement of the slab during service. Sometimes, light mesh reinforcement will be added to prevent the shrinkage and cracking of reinforced concrete due to the weather.

The advantages of composite slab structures are as follow:

1. Light construction is achievable
2. Lesser consumptions in materials and energy compared to conventional steel sections

3. Fabrication cost is saved due to simplicity in erection
4. Time saving by simplified construction method

Besides supporting self weight and concrete weight, profile steel deck adhere with concrete firmly in order to cooperate compositely to carry the load bearing in a better and efficient way. In other words, longitudinal shear forces are transferred between the composite form of profiled steel sheeting and concrete to maintain structure's efficiency.

As lightweight composite slab is not widely used in Malaysia industry, most of the constructions are using conventional reinforced concrete design and precast design. An investigation will be carried out to determine the structural behaviour and the strength of lightweight composite slab system. A total of 2 specimens will be tested experimentally and compared it with theoretical result in accordance to Eurocode Part 4.

1.2 Problem Statement

The combination of concrete slab and steel deck materials in a structural system provides efficient and economical engineering solution for current design. In current design, long duration is needed to construct a building especially setting up and removal of the formwork. However, there's no specific design in lightweight composite slab system because a variety of metal deck and shear connectors can be used. This has lead to lots of research and investigation to their structural performance. In order to obtain the structural behaviour and the strength, actual modeling of composite slabs has been carried out to justify the structure's performance. (V.Marimuthu, 2006)

Lightweight composite slab system with hollow box beam section is a newly proposed model. Moreover, the structure is designed as a floating structure to encounter flood. Experimental testing and investigation have to be carried on in order to determine the suitability of slab system as floating structure and its design approach. The ultimate strength of the structure will be the main factor and determined in this newly design approach.

Theoretical analysis according to Eurocode 4 of composite structures will be compared with the experimental results to identify the performance of lightweight composite structure.

1.3 Research Objectives

The objectives of this study are:

1. To investigate the behavior and structural performance of lightweight composite structure in terms of strength, resistance and failure mode.
2. To verify and compare the experimental results with theoretical results of lightweight composite slab system with hollow-box beam
3. To develop a lightweight composite structure design guide for the propsed slab system

1.4 Scope of study

This research study will investigate on whole lightweight composite slab system with hollow box beam through experimental testing, which consists of composite slab and cold-formed steel beams. A total of 2 specimens will be carried out for the experimental testing. Dimensions of the proposed lightweight composite structure are (4500L x 1500W x 700H)mm. Materials used for the slab system are concrete, wire mesh A6, cold formed steel, tek screw and bracket. The concrete compressive strength of specimens is 40N/mm^2 and the design beam will be hollow box cold formed steel section instead of normal I beam.

The composite slab panel system will be tested until failure under monotonic loading and it will be carried out in Structural Lab, Universiti Teknologi Malaysia. The mode of failure, cracking pattern, maximum load capacity, end-slip capacity and maximum deflection will be recorded during the testing. The proposed system is designed in accordance to Eurocode 4.

Although the proposed composed structure is designed to float on water, the analysis of buoyancy force is not carried out in this research.

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