STRUCTURAL BEHAVIOR OF FERROCEMENT-AUTOCLAVE BLOCK COMPOSITE SLAB

By

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**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Master of Science**

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Dedicated To My Parents and My Wife

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirement for the degree of Master of Science

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Recently, different types of composite floor slabs have been developed and used in the construction industry worldwide. These floor slabs are developed to cater for the shortcomings that are observed in the existing floor slabs. Some of these shortcomings are: long construction time, heavy weight and, bad thermal and sound barrier. All these shortcomings are dependant on the heavy equipment on job site and on formwork and the jointing problems.

Ferrocement-Brick composite slab is one of the recent developments in composite slab systems. The composite is a semi-precast floor slab system which consists of an inverted ribbed ferrocement layer interlocked with bricks used in situ concrete ribs. Aerated autoclaved concrete (AAC) blocks are used, instead of bricks, in a ferrocement-brick composite. The blocks provides a very light weight material (γ=6 kN/m^3), effective thermal insulation and sound barrier compared to normal bricks. Using the aerated autoclaved concrete block will lead to 30% reduction in the weight of the slab compared to the reinforced concrete slab.

This study aims at investigating the structural behaviour of ferrocement-AAC block composite floor slab under flexural loading focusing on the effect of different AAC block layouts in the composite slab on the structural performance of the composite slab. Nine full-scale ferrocement-block composite slabs of different block layouts are cast and tested experimentally under two-point loads. In addition, three ferrocement layers are tested to identify their capabilities to carry the construction loads. The structural performance of the composite slabs is investigated in terms of their deformation and ductility characteristics, cracking characteristics, strain distribution and failure mechanism.

The AAC block layouts play a significant role in the structural behaviour of the ferrocement-AAC block composite slab. It is also concluded that the interlocking mechanism is capable of connecting the two layers and the slab behaved as a full composite slab. The system can sustain the required design load for the residential building.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

KELAKUAN STRUKTUR PAPAK KOMPOSIT BONGKAH AUTOKLAF-SIMENFERO

Oleh

SALEH YHYA LASEIMA

Disember 2006

Pengerusi: **Profesor Madya Waleed A. Malik Thanoon, PhD**

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Pelbagai jenis lantai papak komposit diperkenalkan dan digunakan dalam industri pembinaan di seluruh dunia pada hari ini. Ia dibangunkan bagi mengatasi kelemahan-kelemahan yang terdapat pada lantai konkrit. Antara kelemahan-kelemahannya adalah: masa pembinaan yang panjang, berat yang berlebihan, penghalang kesan thermal dan bunyi yang lemah, dan bergantung kepada jentera berat dan acuan serta masalah penyambungan.

Salah satu penemuan terbaru dalam sistem papak-papak komposit ialah papak komposit bata simenfero. Ia merupakan satu sistem papak lantai pra-tuang yang terdiri daripada lapisan tetulang simenfero terbalik yang terkunci dengan bata di dalam tetulang konkrit.

Di dalam komposit bata simenfero, bongkah AAC (aerated autoclaved concrete) digunakan bagi menggantikan bata biasa. AAC terdiri daripada bahan yang ringan ($\gamma = 6$ kN/m^3) dan mempunyai kelebihan dari segi kesan penebatan haba dan bunyi berbanding bata biasa. Penggunaan bongkah AAC dapat mengurangkan berat papak sehingga 30 % berbanding dengan papak konkrit bertetulang.

Kajian ini dijalankan bertujuan untuk menyiasat tindak balas struktur bongkah lantai papak komposit AAC-simenfero dibawah bebanan lenturan, dengan fokus diberikan kepada kesan susunan bongkah AAC yang berbeza. Sembilan bongkah papak komposit simenfero berskala penuh telah melalui ujian beban dua titik. Tiga lapisan simenfero juga telah disediakan dan diuji untuk mengenal pasti kebolehannya dalam menampung beban pembinaan. Prestasi struktur papak komposit diselidik berdasarkan ciri-ciri ubahbentuk (deformasi) dan kemuluran, keretakan, pengagihahan dan mekanisma kegagalan.

Susunan bongkah AAC memainkan peranan yang penting dalam kelakuan struktur papak komposit bongkah autoklaf-simenfero. Kajian ini juga menunjukkan bahawa mekanisma memanca dapat menyambung antara dua lapisan dan ianya juga menunjukkan tindak-balas sebagai satu papak komposit. Sistem ini dapat menampung beban rekabentuk yang diperlukan untuk bangunan perumahan.

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I certify that an Examination Committee has met on 27th December 2006 to conduct the final examination of Saleh Yhya Laseima on his Master of Science thesis entitled "Structural Behavior of Ferrocement-Autoclave Block Composite Slab" in accordance with Universiti Pertanian Malaysia (Higher degree) Act 1980 and Universiti Pertanian Malaysia (Higher degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Uiversiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institution.

SALEH YHYA LASEIMA

Date: 31 JUNARY 2007

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LIST OF ABBREVIATIONS

AAC	Aerated autoclaved concrete
L	Length of slab
B	Width of slab
b_{r1}	Width of longitudinal ribs
b_{r2}	Width of longitudinal ribs
d_r	Depth of longitudinal ribs
d_f	Depth of ferrocement layer
b_v	Total width of longitudinal ribs
b_{aac}	Total width of AAC
$L_{effective}$	Effective length of slab
d	Effective depth of longitudinal ribs
A_c	Area of slab
A_{sb}	Total area of steel bars
A_{sw}	Total area of steel wire mesh
A_{st}	Total steel area (steel bar + wire mesh)
A_{req}	Required area of steel
$f_{cu(concrete)}$	Characteristic strength of concrete
$f_{cu(aac)}$	Characteristic strength of AAC
f_{yb}	Yield strength of steel bar
f_{yw}	Yield strength of steel wire mesh
U_c	Unit weight of concrete
U_{aac}	Unit weight of AAC
E_s	Modulus of elasticity for steel

V_r	Volume of ribs
V_w	Volume of wing
V_f	Volume of ferrocement layer
V_p	Volume of precast layer
V_i	Volume of cast insitu topping
V_{aac}	Volume of AAC
W_p	Load of precast layer
W_i	Load of cast insitu topping
W_{aac}	Load of AAC
W_D	Total dead load
W_V	Imposed load
W_T	Design load
W_u	Ultimate load
M_u	Ultimate moment
M.f	Modification factor for tension reinforcement
S	Maximum shear force
S_s	Shear stress
S_d	Design shear
C_{AAC}	Compressive force of AAC
$C_{Concrete}$	Compressive force of concrete
T_b	Tensile force of steel bar
T_w	Tensile force of wire mesh
x	Neutral axis
Y	Specimen centroid
I	Moment of inertia

M_{cr}	Crack moment
W_{cr}	Crack load
$k(\mu)$	Thermal conductivity