



UNIVERSITI PUTRA MALAYSIA

**STRUCTURAL PERFORMANCE OF A LIGHTWEIGHT
COMPOSITE SLAB SYSTEM**

YAVUZ YARDIM

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SLAB SYSTEM**

By

YAVUZ YARDIM

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

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TO MY PARENTS



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirement for the degree of Doctor of Philosophy

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July 2008

Chairman: Professor, Waleed A. M. Thanoon, PhD

Faculty : Engineering

Floor structure occupies the biggest dead load and volume in most of the residential buildings. Composite structure is the most proper concept to obtain lighter, cheaper and easy to construct floor system by optimally utilizing available materials. However, composite floor system efficiency under ultimate load remains a major concern. Longitudinal shear failure is the most common type of failure in composite floor slab. The existing shear links systems between cast in situ and precast layers are found very conservative due to absence of adequate investigation. Further investigations of connection systems between the precast composite units are sought. Therefore, Composite Ferrocement Masonry Slab (CFMS) is introduced as a new composite floor system in this study. Inverted two-way ribs precast ferrocement thin panel is used at tension part of the composite slab system and act as permanent formwork. Masonry element such as brick and autoclaved aerated concrete with concrete mortar are used as topping of the composite floor system to achieve lighter structure.



Analytical study has been carried out to investigate the efficiency of Composite Ferrocement Masonry Slab as a composite floor system. A series of pilot tests have been conducted until ultimate load to ascertain structural characteristic of both precast and full slab system. The study proposes a new system to transfer the horizontal shear between the interfaces of the precast and cast in-situ layers of concrete slab as a substitute of shear links. The proposed system implements an interlocking concept and does not require any shear reinforcement. Experimental work carried out by pure shear loading (push off test) and flexural loading to study the effectiveness of the interlocking mechanism in transferring the stresses developed due to the applied load. Flexural test was carried out on full size specimens using different masonry elements to explore structural capacity. Finally, connection tests were carried out for slab to slab and slab-beam-slab connection for the composite precast slab system.

The results in terms of strain distribution, load-deflection 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 residential buildings. The predicted ultimate load using BS8110 was found to be compatible with the experimental results. Ductile load deflection curves were drawn for the composite slab implied maximum deflection varied between 31 to 35 mm for 3 m span. The interlocking mechanism in the proposed composite slab system implied that 20 mm and above interlocking depth is enough to support maximum possible horizontal shear load on the slab structure. The composite slab system with interlocking mechanism acts as a full composite structure until ultimate load. The flexural capacity of this floor slab system is adequate to carry ultimate load 6.5 kN/m^2 for brick masonry composite and 4.5 kN/m^2 for (Autoclaved

Aerated Concrete) AAC masonry composite. The composite slab is achieved using brick and AAC masonry 18% and 22 to 34 % lighter compare to RC slab respectively. The connection tests ascertain connectivity of the composite slab-beam-slab system is well enough to carry residential loads. As a result the proposed composite slab systems may be used as composite precast slab for residential buildings.



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PRESTASI STRUKTUR SISTEM PAPAK KOMPOSIT RINGAN

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Struktur lantai merupakan bahagian yang paling besar dalam kebanyakan bangunan. Struktur komposit adalah konsep yang paling baik untuk mendapatkan sistem lantai yang ringan, murah dan mudah dibina dengan penggunaan bahan yang optimum. Bagaimanapun, keberkesanan integriti sistem lantai komposit antara elemen komposit di bawah beban muktamad masih memerlukan perhatian. Kegagalan ricih memanjang adalah jenis kegagalan yang paling biasa di dalam struktur lantai komposit. Sistem rangkaian ricih yang ada antara lapisan pasang siap dan konkrit yang diletakkan adalah sangat konservatif kerana itu kajian diperlukan. Jadi, kajian sistem hubungan antara unit-unit komposit pasang siap adalah perlu. Oleh itu, lantai konkrit simenfero komposit diperkenalkan sebagai satu sistem lantai komposit baru untuk bangunan tempat tinggal dalam kajian ini. Lantai nipis simenfero pasang siap rib dua arah digunakan pada bahagian tegangan sistem lantai komposit dan bertindak sebagai acuan kekal. Elemen konkrit seperti batu bata dan konkrit dengan mortar konkrit digunakan pada bahagian atas sistem lantai komposit untuk mencapai struktur lebih ringan.



Kajian analitikal telah dijalankan untuk mengkaji keberkesanan lantai konkrit simenfero komposit sebagai sistem lantai komposit. Beberapa siri ujian dilakukan sehingga beban muktamad untuk mendapatkan sifat-sifat struktur sistem lantaipenuh dan pasang siap. Kajian ini mencadangkan satu sistem baru untuk memindahkan ricih memanjangantara permukaan pasang siap dan lapisan konkrit baru lantai konkrit tersebut sebagai satu gantian kepada rangkaian ricih. Sistem yang dicadangkan adalah berkonsepkan kekunci dan tidak memerlukan sebarang tetulang ricih. Kerja eksperimen dilakukan dengan pembebanan ricih asal (ujian tolakan) dan pembebanan lenturan untuk mengkaji keberkesanan mekanisma kekunci dalam pemindahan tegasan yang wujud apabila beban dikenakan. Ujian lenturan dilakukan ke atas specimen bersaiz penuh menggunakan elemen konkrit yang berbeza untuk meningkatkan kapasiti struktur. Akhirnya, ujian dilakukan untuk sambungan lantai dan lantai serta lantai dan rasuk untuk sitem lantai komposit pasang siap.

Keputusan bagi agihan terikan, lengkungan-beban dan beban-beban kegagalan menunjukkan bahawa tindakbalas lantai kmposit kepada beban adalah memuaskan dan boleh digunakan sebagai satu lantai dalam bangunan. Beban maksima yang diramalkan menggunakan BS8110 adalah sejajar dengan keputusan eksperimen. Graf lengkungan beban rapuh dilukis untuk lantai komposit menunjukkan lengkungan maksima adalah antara 31 – 35 mm. Mekanisma kekunci dalam sistem lantai komposit yang dicadangkan adalah 20mm dan kedalaman kekunci adalah cukup baik untuk menyokong beban ricih mendatar maksima bagi struktur lantai. Sistem lantai komposit dengan mekanisma kekunci bertindak sebagai satu struktur komposit penuh sehingga beban maksima akhir. Kapasiti lenturan sistem lantai cukup untuk menanggung momen maksima 6.5kN/m^2 untuk komposit konkrit bata dan 4.5kN/m^2



untuk komposit konkrit (Autoclaved Aerated Concrete) AAC. Lantai komposit dicapai menggunakan bata dan konkrit AAC masing-masing 18% dan 22-34% lebih ringan dibanding lantai konkrit tetulang. Ujian menunjukkan sambungan antara sistem lantai dan rasuk komposit adalah cukup baik untuk menanggung beban-beban dalam bangunan tempat tinggal. Oleh yang demikian, sistem lantai komposit yang dicadangkan boleh digunakan sebagai lantai pasang siap komposit untuk bangunan.



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- Yavuz Bardim



I certify that an Examination Committee has met on 24 July 2008 to conduct the final examination of Yavuz YARDIM on his Doctor of Philosophy thesis entitled “Structural Performance of a Lightweight Composite Slab System” 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.

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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 institutions.

YAVUZ YARDIM

Date: 27 August 2008



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