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Faculty of Engineering

# BEHAVIOR OF COMPOSITE LAYERED SLAB OF EPS CONCRETE AND NORMAL CONCRETE

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**Bachelor of Engineering with Honours**
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# BEHAVIOR OF COMPOSITE LAYERED SLAB OF EPS CONCRETE AND NORMAL CONCRETE

**CHIA HUI CHING**

This project is submitted in partial fulfillment of
the requirements for the Degree of Bachelor of Engineering with
Honours (Civil Engineering)

*To my beloved family*

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**ABSTRAK**

Penggunaan konkrit berkomposisi polistrin telah menjadi semakin berleluasa dalam industri pembinaan pada zaman ini. Polistrin telah digunakan untuk mengganti bahagian bawah spesimen konkrit tetulang biasa pada kajian yang lepas. Konkrit komposisi polistrin ini biasanya digunakan sebagai konkrit berjisim ringan bertujuan untuk membina struktur struktur gergasi. Objektif utama kajian ini dilakukan ialah untuk mengkaji perbezaan daya kekuatan dan koduksi haba antara konkrit berkomposisi biasa dan polistrin dengan konkrit biasa. Konkrit berkomposisi polistrin disediakan dengan menggantikan 50% batu dan 50 % pasir denagan polistrin. Daya tekanan dikenakan ke atas spesimen-specimen ini dan pemerhatian telah dibuat. Kajian menunjukkan kekuatan konkrit berkomposisi biasa dan polistrin adalah lebih rendah jika dibandingkan dengan kekuatan konkrti biasa. Manakala kajian juga telah menunjukkan konduksi haba konkrit berkomposisi polistrin adalah lebih lambat jika dibandingkan dengan konkrit biasa. Beberapa kesimpulan dan cadangan untuk meningkatkan kualiti dan penggunaan konkrit komposisi polistrin ini telah dicatatkan dalam laporan ini.

# ABSTRACT

The use of expanded polystyrene (EPS) beads in fully or partially replacing the normal aggregate is prevalent in the construction industry nowadays. The present study covers the use of EPS concrete layer to replace the bottom concrete cover of normal reinforced concrete slab. The aim of this project is to study the flexural strength and thermal conductivity of the composite layered slab of EPS concrete and normal concrete. The EPS concrete is prepared by 50% replacing the coarse aggregate and 50% replacing the fine aggregate by volume with EPS beads. Two loading patterns are applied on the specimen: shear dominant loadings and bending dominant loadings. The flexural strengths of the composite layered slab for specimen subjected to shear dominant (SDEC) and specimen subjected to bending dominant (BDEC) is reduced 5.60% and 25.66% respectively as compared to the normal reinforced concrete slab. The results show that the replacement of EPS concrete with the normal concrete cover performs well under the shear dominant but reduce when subject to bending dominant. The thermal conductivity for composite layered specimen shows the temperature increment less than the normal concrete specimen. The EPS concrete layer acts as the bottom cover has decrease 5.00% from point at 75mm to 25mm from top. The closed air-filled cell structure of EPS beads inhibits the passage of heat and provides better thermal insulation. The composite layered slab of EPS concrete and normal concrete is recommended to utilize as roof slab.

# TABLE OF CONTENT

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS AND NOTATIONS

| | | |
|---|---|---|
| mm | - | Millimeter |
| KN | - | Kilo Newton |
| m | - | Meter |
| kg | - | Kilogram |
| °C | - | Celcius |
| % | - | Percent |
| EPS | - | Expanded Polystyrene |
| SDNC | - | Shear dominant normal concrete |
| SDRC | - | Shear dominant reinforced concrete |
| SDEC | - | Shear dominant Expanded Polystyrene concrete |
| BDNC | - | Bending dominant normal concrete |
| BDRC | - | Bending dominant reinforced concrete |
| BDEC | - | Bending dominant Expanded Polystyrene concrete |

# LIST OF APPENDIX

# CHAPTER 1

# INTRODUCTION

## 1.0 General

Reinforced concrete is used in building construction due to its high compressive strength, form flexibility, durable and characteristics beneficial to environmentally sound practices. Reinforced concrete slabs are plate elements forming floors and roofs in building which normally carry uniformly distributed loads and concentrated loads acting normal to the plane of the slab.

## 1.1 Background

The ACI Code emphasizes design based on strength with serviceability checks and one of the important design considerations is the performance of structures at the service loads (Park & Gamble, 2000). Even the degree of safety against collapse is adequate but the performance of the structures at the service load may be failed. The slab system may exhibit excessive cracking or the deflections may be unacceptably large when subjected to service loads. Therefore, the slab should be designed with taking account of several limit states, the most important being strength at overloads, deflections at service loads, and crack widths at service loads.

Vibration and fatigue at reinforcing steels at service loads are the other possible limit states that should be considered. To check for deflections the minimum allowable slab thickness is specified to ensure adequate stiffness and ensure the deflections not exceeding specified maximum allowable values. The arrangements of reinforcement are limited to ensure that the crack widths are not excessive.

The concrete tensile stresses will be an appreciable fraction of the modulus of rupture, and cracking may occur at some time after first loading as a result of sustained tensile stresses. The occurrence of cracks in some regions of reinforced concrete slab systems is inevitable because of the low tensile strength of concrete so the tensile resistance of concrete is normally neglected in design. The tension zone is reinforced with reinforcement to provide the tensile forces needed for moment equilibrium after the first crack developed.

## 1.2 Problem statement

For reinforced concrete ground slab the moisture migration always cause problem for the adhesion of floor covering materials. The sources of moisture are the concrete slab residue moisture, groundwater source and water vapor of damp soil. Concrete ground slab placed on different type of soil will have different level of moisture inflow. Placing on clay soil has highest moisture inflow and placed on gravel capillary break will reduce the initial moisture inflow by about one third of the clay soil's moisture inflow (Brewer, 1965).

To prevent the moisture inflow the contractors normally place vapor barrier over a gravel layer or compacted layer. However, the concrete slab places directly over a vapor barrier will result the greater water flow at the early age since mix water in concrete is restrained to be lost to the subgrade below. Besides, the fast track construction schedules exacerbate the problem as the contractor will install the floor-surfacing material before the concrete slab has dried to acceptable level.

In addition, the roof slab is the most highly stressed part of a building. Heat and cold, dryness and wetness, storm act from the outside, internal relative humidity acts from inside which are the considerations to take into account for making the roof fulfill its protective functions. The water absorption, thermal conductivity and strength are the main considerations for roof slab design. However, normal concrete achieve higher value in water absorption and thermal conductivity which makes the roof slab theoretically not ideal in term of protection of a building. To compensate the weakness of normal concrete, EPS concrete is utilized to upgrade the performance of reinforced concrete slabs.

EPS concrete is one of the lightweight concrete with density not exceeding 1900kg/m$^3$ but low in compressive strength (not more than 30MPa) as compared to the normal weight concrete. EPS concrete has low water absorption, thermal insulation, low moisture migration and good energy absorbing characteristics.

According to Fowler, polymer-impregnated concrete is the first concrete polymer composite to receive wide-spread attention with some commercial interest. Resistance to acid chemical attacks is one of the several distinguishing properties of this material.

The researches on EPS concrete can be traced back to 1973, when Cook investigated EPS as an aggregate for concrete. EPS beads have microcellular closed cell and making its excellent insulation properties which is an essential properties for roof slab while the low moisture migration improve the performance of ground slab.

In view of its low compressive strength the EPS concrete is unable to perform solely for reinforced concrete slab. Therefore, the composite layered slab of EPS concrete and normal concrete is proposed to improve the serviceability and behavior of the reinforced concrete slab.

## 1.3 Scope of study

The bottom cover of reinforced concrete slab is proposed to be replaced by the EPS concrete. The EPS concrete has the greater thermal insulation and lower water impermeability as compared with normal concrete. It is believed that the characteristics of EPS concrete are able to improve the serviceability of the reinforced concrete slab. The replacement of bottom cover with EPS concrete will not affect the performance of normal reinforced concrete slab in ultimate limit state because the purpose of the cover is mainly for protecting the reinforcement against corrosion and against the fire.

Moreover, the bottom reinforced concrete slab is only sustaining the tensile stress created by the top of loading and EPS concrete is able to provide the adequate tensile strength. Nevertheless, the tensile strength of concrete will not contribute much since the tensile zone is reinforced with steel bars.

The scope of study covers the behavior of the composite layered slab of EPS concrete and normal concrete in term of the thermal conductivity and flexural strength performance. For EPS concrete it did not exhibit typical failure mode as normal weight concrete. It is observed to be more gradual (compressible) and capable of sustain the loads after failure without full disintegration (Babu et al, 2005).

## 1.4 Aim & objectives

The main objectives of the present work are

I. To study the thermal conductivity characteristics of layered slab comprising of EPS concrete and normal concrete

II. To check the strength

## 1.5 Outline of project

Chapter 1 introduces the basic knowledge on what are the conventional reinforced concrete slab and its weakness in durability and behavior. Then, it will introduce the new reinforced concrete slab whereby produce by composite the EPS concrete and normal concrete. The scope of study will be further discussed as well as the aim and objectives.

Chapter 2 provides the data and results done by researchers on the EPS concrete and the flexural strength of reinforced concrete slab. Meanwhile, the EPS concrete will compare with the normal concrete in many aspects. The weakness of