# PROPERTIES OF POLYSTYRENE CONCRETE BRICKS WITH SILICA FUME

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Ms. Idawati Ismail
Supervisor

Date

*Dedicated to my beloved parents, my dearest siblings and Jacqueline Lam*

*who had give me strength to carry on.*

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# ABSTRAK

Laporan projek ini menunjukkan keputusan eksperimen penyelidikan ke atas sifat bata-bata konkrit yang mengandungi biji-bijian polistirena padat dan wasap silika. Dalam kajian ini, konkrit polistirena yang ringan dapat dihasilkan dengan mengantikan sebahagian agregat kecil dengan bahan lain. Biji-bijian polistirena padat digunakan sebagai agregat ringan bagi pengantian pasir. Tambahan pula, simen digantikan sebagai wasap silika supaya meningkatkan sifat konkrit. Sejumlah 216 bata disediakan untuk kajian ini. Tujuan utama projek ini adalah mengkaji sifat bata-bata konkrit polistirena seperti kekuatan mampatan, berat dan kepadatan, peyerapan air, hakisan sulfat, hakisan air laut, dan akhirnya pengembangan dan pengecutan bata-bata konkrit polistrena. Sampel-sampel dikaji dalam empat keadaan seperti keadaan makmal, air paip, air laut, 5% asid sulfurik. Sampel-sampel ini dibandingkan antara satu sama lain dengan mengguna air paip sebagai sampel kawalan. Kajian ini mendapati bahawa bata-bata konkrit polistirena adalah lemah dalam kekuatan mampatan, namun dengan kehadiran wasap silika, kekuatan mampatan dapat ditingkatkan dan penyerapan air dapat dikurangkan. Selain itu, terdapat juga perubahan sifat-sifat fizikal seperti warna dan dimensi. Kajian ini menunjukkan bahawa sifat-sifat bata konkrit polistirena dipengaruhi oleh kandungan wasap silika dan kandungan biji-bijian polistirena padat di dalam sampel. Kajian ini juga menunjukkan kebolehan penggunaan bahan kitaran dalam industri pembinaan.

# ABSTRACT

This project reports the results of experimental investigation on the properties of concrete bricks containing expanded polystyrene beads and silica fume. In the study, lightweight polystyrene concrete can be produced by partial replacement of fine aggregate. Expanded polystyrene beads were used as lightweight aggregate for replacement of sand. In addition, cement was partially replaced by silica fume in order to improve the properties of concrete. A total of 216 samples of bricks were prepared for this study. The main purpose of this project is to investigate the properties of polystyrene concrete bricks such as the compressive strength, weight and density, water absorption, sulphate attack, sea water attack and finally, expansion and contraction of polystyrene concrete bricks. The samples were tested in four conditions such as laboratory condition, tap water, sea water and 5% sulphuric acid. These samples were compared to each other by taking tap water condition as control. It was found that the bricks have low compressive strength with high water absorption but with presence of silica fume, the strength was increased and the water absorption was decreased. There are also changes in physical properties such as colour and dimension. The experimental study shows that the properties of polystyrene concrete bricks were mainly influenced by the content of silica fume and expanded polystyrene beads in the mix. This study also shows the potential use of recycle materials in construction industry.

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# LIST OF SYMBOLS

| | |
|---|---|
| $m_1$ | Wet brick weight |
| $m_2$ | Dry brick weight |
| N | Newton |
| m | meter |
| mm | millimeter |
| kg | kilogram |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Concrete is a building material that is widely used in the construction field. Concrete is produced by mixing cement and water with various inert materials such as aggregates. The most commonly used inert materials are sand and gravel. As time goes by, a lot of changes have been done to the proportion of concrete mix in order to improve the performance of the hardened concrete.

Construction technology is growing in advance nowadays and many researches have been conducted to replace the conventional material (cement, sand and gravel) with waste material in partly or fully proportion. Solid wastes from daily lives and by-products from industries which cannot be disposed or not properly managed will consequence in environmental pollution. Therefore, using wastes such as expanded polystyrene (EPS) to replace the aggregates can be an alternative way of waste management and using industries by-product such as silica fume as supplementary cementitious material.

## 1.2 Problem Statement

Nowadays, the amount of solid wastes such as polystyrene, plastic bags, bottles and so forth are increasing drastically but the actions taken to manage the waste materials are not effective. This directly affects the pollution to environment and may consequence in health problem. Besides, industrial by-products such as silica fume, carbide, slag, fly ash and others are also produced in large amount everyday. These by-products can be used as admixture for concrete mix since the properties of the materials are essential to improve the performance of concrete.

Furthermore, lightweight concrete bricks are very demanding nowadays. The usage of lightweight concrete is very wide because eventually, it is much cheaper than ordinary concrete. The self weight or density of the lightweight concrete is also one of the main issues to be studied. Lightweight concrete is required to be light and possess sufficient strength for its use. However, lightweight concrete strength level, workability and durability are still below satisfactory level. Hence, further improvement is needed to be done to produce lightweight concrete with desired properties.

This study is conducted to examine the ability of the wastes and by-products in improving the strength, workability and durability of concrete. In addition, this study may contribute to management of solid wastes and industries by-products in the future.

## 1.3 Objectives

Followings are objectives to be achieved in this study:-

i) To develop the concrete bricks mix which consists of EPS to replace partial proportion of aggregates with gradually added percentage of silica fume.

ii) To determine the mechanical properties and durability of EPS concrete bricks with silica fume.

## 1.4 Scope of study

This study focuses on investigating the properties of the proposal concrete mix of high strength lightweight concrete. Among the properties investigated for were compressive strength, and permeability for durability while maintaining the high workability. Besides, the resistance of the concrete mix to the chemical attack will be conducted in this study as well. In addition, the study will also consider the water-cement ratio and the important role of the hydration process that produces hardened concrete of higher strength and durability.

This study was conducted by replacing the fine aggregates with expanded polystyrene (EPS) in partial proportion. EPS concrete is a lightweight, low strength material with good energy-absorbing characteristic. Due to the light weight nature and hydrophobic surface of EPS beads, EPS concrete is prone to segregation during casting

which results in poor workability and lower strength. The water is an important element that might affect the strength of the hardened concrete. Therefore, wet expansion and dry shrinkage were monitored.

In this study, silica fume was added to EPS concrete to improve the bond between the EPS beads and cement paste and increased the compressive strength of EPS concrete. The addition of silica fume was to improve the strength of the concrete. The purpose of this study was to investigate the physical and mechanical properties of EPS concrete bricks with silica fume. The physical properties investigated on the EPS concrete bricks with silica fume were changes on the dimension and colour. On the other hand, mechanical properties of EPS concrete bricks with silica fume such as workability, compressive strength, weight and density, durability against chemical attack and sea water attack, water absorption, and dimension would be determined. The test and investigation of properties of concrete are according to the Malaysian Standard; Specification for Bricks and Blocks of Fired Brickearth Clay or Shale Part 2, Metric Units (MS 76: 1972).

## 1.5 Project Outline

This thesis consists of five chapters. Chapter 1 presents the general information regarding the background, problem statement, objectives, scope of study and the project outline. This chapter also outlines the duration and work progress of the project.

Chapter 2 provides the literature reviews on the different topics that are related to this study. This chapter reviews on the materials properties and information of concrete. This chapter also outlines the behavior of concrete with the lightweight aggregate such as expanded polystyrene and silica fume as the cement replacement material.

Chapter 3 describes the methodology used to carry out this study. It provides overall experimental program for the study. This chapter includes the procedures of the preparing testing the samples. Proper methods and procedures are outlined in this chapter as well.

Chapter 4 presents the results and discussion from the laboratory testing. This chapter includes the properties of concrete bricks derived from the results obtained from the laboratory testing. This chapter also includes the changes of physical properties of the samples observed in the study.

Chapter 5 presents the conclusion of the major findings in this study and recommendation for future work on the related topic to the present study. This chapter also discuss about the limitations of faced in this study.

## 1.6 Gantt Chart of Progress

| Activity/ Duration | JULY 2008 | AUG 2008 | SEPT 2008 | OCT 2008 | NOV 2008 | DEC 2008 | JAN 2009 | FEB 2009 | MAC 2009 | APR 2009 | May 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Literature Review | | | | | | | | | | | |
| Lab Preparation.<br><br>Data Collection. | | | | | | | | | | | |
| Data Analysis | | | | | | | | | | | |
| Report Writing. | | | | | | | | | | | |

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Concrete is one of the economical materials that can be easily obtained from the industry for construction. Concrete is also stable and high strength material which is produced by mixture of cement, aggregates and water, hence it is suitable to be used in construction. Concrete brick is produced from the same method from a controlled mixture of cement, aggregates and water. Concrete can be used for other purposes such as manufacturing of concrete blocks for constructing concrete wall and even paving too.

There are certain measures to classify the concrete quality. The quality of concrete must satisfy the performance requirement in its fresh state and also hardened state after placing. The most important measure to determine the quality of concrete is the compressive strength of the hardened concrete. When concrete is hardened, the concrete should gain the satisfactory workability, durability and strength.

## 2.2 Concrete

Concrete is a controlled proportion mixture of cement, aggregates and water. A normal concrete mixture generally takes 6 to 10 hours for setting and 1 to 2 days for achieving a strength level (Mehta and Monteiro, 2006). Fresh concrete has good workability if it can be formed, compacted and finished into its final shape and texture with minimal effort and without segregation. Good workability is required to produce concrete that is both economical and high in quality. Fully cured hardened concrete must be strong enough to withstand the structural and service loads which applied to it and must be durable to withstand the environmental exposure for which it is intended (Beall, 2004).

Concrete can be classified into three broad categories based on the unit weight. Concrete containing natural sand and gravel or crushed rock aggregates, generally weighing about 2400kg/$m^3$ is called normal-weight concrete and it is commonly used for structural purposes. Heavy weight concrete used for radiation shielding, is a concrete produced from high-density aggregates and generally weighs more than 3200 kg/$m^3$. The term lightweight concrete is used for concrete that weighs less than 1800kg/$m^3$. It is produced by reducing the unit weight of concrete using natural or pyro-processed aggregates with lower bulk density (Mehta and Monteiro, 2006).

Increment in the fineness of the Portland cement usually increases the early strength of the concrete. It is due to higher surface area in contact with water of the concrete which lead to a more rapid hydration (Neville, 2003). It is best to use fine