WATER PERMEABILITY OF FOAMED CONCRETE

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Dedicated to my beloved

Father

Mother

Wife, Nurfirdawati

My daughter Syafiqah Sofia

My son Amir Amzar

For the patience and support....

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ABSTRACT

This study focused on the compressive strength and water permeability of foamed concrete. Two types of foamed concrete mix with density 1500 kg/m^3 and 1700 kg/m^3 were experimented. Timber industrial ash (TIA) were used as the partial cement replacement material, replacing 10% of Ordinary Portland cement (OPC) in the mix design. The test cubes were 150 mm X 150 mm X 150 mm size subjected to wet-cured and air cured for up to 28 days. The density, compressive strength development and water permeability of the TIA foamed concrete were determined to compare with the control mix (without TIA). The test method adopted based on DIN 1048 was used to determine the water permeability of foamed concrete at 28 days. Compressive strength was determined at 3 days, 7 days and 28 days. It was found that the air-cured specimens achieved a higher compressive strength and lower water permeability compared with the wet-cured specimens. Foamed concrete with 10% TIA reduced the water permeability with a lower compressive strength at 28 days. The preliminary result indicated that TIA has potential to reduce the water permeability of foamed concrete.

ABSTRAK

Kajian ini menumpu kepada kekuatan mampatan dan kebolehtelapan air konkrit berbusa. Dua jenis bancuhan dengan ketumpatan 1500 kg/m^3 and 1700 kg/m^3 digunakan dalam kajian ini. Habuk kayu industri (TIA) telah digunakan sebagai bahan gantian simen bagi menggantikan 10% daripada kandungan Portland simen biasa (OPC) dalam rekabentuk bancuhan. Kiub 150 mm X 150 mm X 150 mm diawet dalam keadaan lembap dan juga udara sehingga 28 hari. Ketumpatan, kekuatan mampatan, dan kebolehtelapan air konkrit berbusa telah ditentukan untuk dibandingkan dengan bancuhan kawalan (tanpa TIA). Kaedah ujikaji berdasarkan DIN 1048 telah digunakan bagi menentukan kebolehtelapan air konkrit berbusa pada umur 28 hari. Kekuatan mampatan ditentukan pada umur 3 hari, 7 hari dan 28 hari. Didapati spesimen yang melalui pengawetan dengan udara mencapai kekuatan mampatan yang lebih tinggi dan kebolehtelapan air yang lebih rendah berbanding dengan spesimen dalam pengawetan lembap. Pada umur 28 hari kebolehtelapan air konkrit berbusa dengan kandugan 10% TIA adalah menurun dengan kekuatan mampatanya yang lebih rendah. Hasil dari saringan ini didapati bahawa TIA mempunyai potensi untuk mengurangkan kebolehtelapan air konkrit berbusa.

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LIST OF ABBREVIATIONS AND SYMBOLS

TIA	Timber Industrial Ash
PFA	Pulverized Fuel Ash
GGBS	Ground Granulated Blast Furnace Slag
RHA	Rice Husk Ash
ACI	American Concrete Institute
AAC	Autoclaved Aerated Concrete
SAA	Surface Active Agent
OPC	Ordinary Portland Cement
mm	millimeter
ASTM	American Society for Testing and Materials
BS	British Standard
C2S	Dicalsium Silicate
C3S	Tricalsium Silicate
CH	Calsium Hydroxide
C-S-H	Calsium Silicate Hydrate
MS	Malaysia Standard
MPa	Mega Pascal
g	Unit weight, gram
k	Coefficient of permeability
ρ	Density of foamed concrete;
m	Mass of cube after remove from the mould in unit kg;
v	Volume of the specimen calculated from its dimensions in (m^3);
ISO	International Standard Organization
°C	Degree Celcius

dq/dt	The rate of fluid flow
A	Cross sectional area
L	The thickness of the sample in m
Δh	The drop in hydraulic head through the sample, measured in m
BCA	British Cement Association

CHAPTER I

INTRODUCTION

1.1 General

Concrete is an important building material, playing a part in all building structure. It can be molded to take up any shape required for the various structural forms. According to the "Draft International Standard Model Code for Concrete Construction" classifies concrete as having densities around 2300 kg/m^3.

Foamed concrete is a lightweight product produced by adding a foaming agent (usually some form of hydrolyzed protein or resin soap) to the mix. The agent introduces and stabilizes air bubble during mixing at high speed. In some processes, stable pre-formed foam is added to the mortar during mixing in an ordinary mixer.

Lightweight concrete may be defined as the concrete of substantially lower unit weight than that made from gravel or crushed stone. Concrete is considered lightweight if it's density falls between 1200 kg/m^3 to 2000 kg/m^3.

Ordinary concrete is quite heavy and it is not suitable for use in floor filling as filler in general because it will affect the dead weight of the structure. By using suitable aggregates, the density of concrete can be reduced. Beside that the foamed concrete also has a better insulation against heat and sound.

K. Schonlin et al (1988) stated that the durability of concrete structures has become a serious problem in many parts of the world. A number of deleterious processes in concrete are related to the pore structure and in particular to the diffusion characteristics and the permeability of the concrete.

Permeability is a measure of the capacity of a porous medium to transmit water. It is regarded as a material property affecting the durability of concrete and it is considered as one of the most important properties of the concrete.

J.F Young (1988) stated that the permeability is an important property with regard to the durability of concrete. It represents the ease with which water (or other fluids) can move through the concrete, thereby transporting aggressive agents. It is thus of critical importance for many types of distress experienced by concrete.

In this study there are many aspect which has been discussed by the researcher but what is relevant to this study is on the water permeability and compressive strength of the foamed concrete with densities 1500 kg/m^3 and 1700 kg/m^3 and with different composition, water cement ratio and ages.

1.2 Statement of Problem

Foamed concrete is new method of concrete that can be used in construction. "British Cement Association" (1991), were published the report about foamed concrete where all the properties of foamed concrete were reported but this report is lake of information about durability. We have identifying the durability is closed related to water permeability, therefore the water permeability of foamed concrete has to be investigate in detail and it is a intension to construct more water retaining structure of foamed concrete.

The durability and quality of concrete structures has become a major topic of interest in concrete industry. Mehta P. K (1997) stated that for the future, the durability of concrete would become a critical issue. These issues were come up when many structures had shown serious deterioration much before their intended service life (40 to 50 years). Mainly due to economic factors, the durability of concrete is being taken seriously.

Many factor affecting the concrete durability. Concrete durability depends largely on the ease with which fluids in the form of liquid or gas can migrate through the hardened concrete mass. Concrete is porous material. Therefore, moisture movement can occur by flow, diffusion or sorption. We are concerned with all three, but generally the overall potential for moisture in concrete by these three modes is referred to as its permeability. Permeability is a one of the significant factors that affecting the durability of concrete where the information or data about these is very important for the structure use. Generally, many methods have been done to determine the water permeability of concrete and one of the methods is DIN 1048 but the applicable of this method for the foamed concrete is unknown.

Timber industrial ash (TIA) is considered as a waste industries material and it were through the integrated micronising blending process to producing micronised silica. The micronised silica that is produced can be used as a cement replacement material in concrete. If TIA is used to replace cement in concrete it can utilize the waste material.

TIA has been found to increase the durability of normal concrete but for foamed concrete, it's still unknown especially in water permeability because a foamed concrete with TIA still a new material of concrete. This information is very important to determine the quality of foamed concrete and to increase the performance of foamed concrete.

1.3 Objective of Study

The objectives of this study are:

i. To determine the water permeability of foamed concrete

ii. To study the effect of micronized silica TIA on the foamed concrete

1.4 Scope of Study

A study was conducted to develop a new kind of building material base on foam. Laboratory test were carried out to determine the compressive strength and water permeability of foamed concrete at 1500 kg/m^3 and 1700kg/m^3 of densities. The 10% of TIA also were used as a replacement cement to produce a foam concrete which comparison were be done with a control sample (0% replacement material). The details of mix proportion are shown in Table 3.2. For each series of mix, 12 cube specimens were been cast. The detail of amount of cube is shown in Table 3.4. At age 3, 7 and 28 days, 2 cubes for each series were subjected to compressive strength. After age 28 days 4 cubes for each series were subjected to water permeability using DIN 1048 method where two cubes were cured with air curing and the other two cubes were carried out under water curing.

1.5 Hypothesis of Study

The hypothesis of this study is a foamed concrete have low water permeability and TIA has a potential or tendency to reduce water permeability

1.6 Important and Contribution

From this study we can identify the process of manufacturing a foamed concrete. Beside that, this research also can be used for:

i. Manipulating the foamed concrete characteristic into practice by improving the compressive strength and water permeability of foamed concrete.

ii. Introducing new alternative materials of concrete in construction.

iii. Introducing the use of TIA in foamed concrete can be widely in the structural construction if found it is suitable

iv. Utilizing waste / secondary material in a production of aggregate that can meet the relevant requirement for structural use, therefore save the environment.

1.7 Layout of Report

This report is presented in five chapters. The objective and scope of work are covered in Chapter I. In this chapter also, the hypothesis of study, the problem statement and significant of study are specified. Literature review are summarize in Chapter II. The methodology, experimental and test methods are described in Chapter III. The water permeability test system is discussed in Chapter VI. The strength development and water permeability of foamed concrete are reported in Chapter V. The conclusion of the study is discussed in Chapter VI.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Concrete is the product of reaction between hydraulic cement and water. But these days concrete can be made with several types of cement and also containing pozzolan, fly ash, admixtures, polymers, fibres and so on.

Many research have been done to produce a concrete, with technical environmental and economical advantages. Scientist, engineer and technologist are continuously on looking for the method or new material, which can be used to produce a concrete with enhanced performance especially in durability.

David et. al. (1988) has state that the concrete technologist throughout the world are becoming increasingly aware of the importance of permeability with regard to the durability and ultimate longevity of concrete structures. New materials for reducing permeability and techniques for its measurement are rapidly being developed.

Foamed concrete is a new alternative construction material that was introduced nowadays but the study about this concrete still not so many. Foamed concrete is manufactured by entraining relatively large volumes of air into the cement paste by the use of a chemical foaming agent. High air contents result in lower densities, higher porosities and lower strengths.

Kearsley et. al (2000) stated that the porosity of foamed concrete after replacing large volume of cement (up to 75% by weight) with both classified and unclassified fly ash was found to be dependent mainly on the dry density of the concrete and not on ash type or content. The volume of water absorbed by foamed concrete was approximately twice that of an equivalent cement paste but was independent of volume of air entrained, ash type and ash content. The compressive strength of foamed concrete when cured under sealed condition shows that up to 67% of the cement could be replaced without any significant reduction in strength

Permeability is an important property with regard to the durability concrete. It represents the ease with which water can move through the concrete, thereby transporting aggressive agents. It is thus of critical importance for many types of distress experienced by concrete.

Neville A. M (1981), found that the permeability of concrete is not a simple function of its porosity, but depends also on the size, distribution and continuity of the pores. Thus, although the cement gel has a porosity of 28 per cent, its permeability only about 7×10^{-16} m/s. The permeability of cement paste also is varies with the progress of hydration. In a fresh paste, the flow of water is controlled by the size, shape and concentration of the original cement grains and in the mature paste, the permeability depends on the size, shape and concentration of the gel particles and on whether or not the capillaries have become discontinuous.

The use of blended cement, which contains partial cement replacement materials (PCRM) such as pulverized fuel ash (PFA), ground granulated blast furnace slag

(GGBS), rice husk ash (RHA) and timber industrial ash (TIA) has been widely accepted in concrete construction. The use of such pozzolanic materials in concrete has been found to improve the durability performance of concrete, especially in terms of reduced hydration temperature.

Lee et al. (1997) revealed in TIA study, the appropriate use of TIA tends to enhance strength development and reduce water permeability of concrete if the cement replacement level is not more than 10%. Water permeability of around $1X10^{-13}$ m/s can be achieved for grade 80 concrete containing 5% TIA. Concrete of reduced water permeability are suitable for products and structures subjected to constant water pressure such as the pre-cast concrete piles and other concrete structures. He also stated that the TIA concrete was found to produce lower hydration temperature. The maximum hydration temperature is occurred at about 10 hours after the concrete specimens were cast if concrete containing less than 20% TIA but for concrete containing 20% TIA, the maximum hydration temperature occur at 7 days after casting.

Lee et al (1999) stated that the water permeability of concrete cover is related to durability and usually associated with good concrete practice, which involves a suitable choice of constituent material together with good concrete mix design and workmanship. Good concrete practice should include adequate compaction and suitable curing. Early and long (first 7 to 14 days) moist curing has been identified as an important requirement for durable concrete. He also stated that, the permeability of cement paste is related to concrete durability. A great deal of work has been done measuring and predicting permeability of cement paste. One aspect of the work related pore structure to its permeability.

Nyame B. K (1985), investigated the permeability of normal and lightweight mortars. It was found that the permeability of mortar increased as the porosity was reduced by the addition of aggregates that have a lower porosity than the mortar. Nyame suggested that the inclusion of the aggregate creates microcracks at the interface with the mortar resulting in increased permeability. By increasing the aggregate volume there are more interfaces resulting in higher permeability. Aggregates therefore have two opposing influences upon permeability: size and volume obstructions can reduce permeability but interfacial effects and aggregate properties can increase permeability. In the case of foamed concrete the small air voids that are entrained can effectively be considered as an aggregate, their inclusion might not reduce the permeability by obstructing flow but they are also unlikely to lead to an increase because of the absence of microcracking

According to Neville A.M (1995), entrained air in concrete produces, in the cement paste, discrete, nearly spherical bubbles approximately 50 micrometer in diameter resulting in the formation of very few channels for the flow of water and very little increase in the permeability. The volume of air normally associated with air entrainment is no more than about 6% and what needs to be established is whether or not this statement holds true for foamed concretes which contain much larger volumes of air.

In the study on capillary pore structure and permeability of hardened cement paste Nyame et. al (1981) concluded that porosity is not a unique function of permeability. They concluded that total porosity of hardened cement paste is not uniquely related to permeability but depends on whether the change in porosity derives from differences in the water/cement ratio or hydration times. They identified well-defined trends for the effect of the time of hydration at constant water/cement ratio on permeability

Day R.L et al (1988) conducted research on the pore structure characteristics affecting the permeability of cement paste containing fly ash. They concluded that the pozzolanic reaction of fly ash in blended cement pastes could cause substantial reductions in permeability.

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