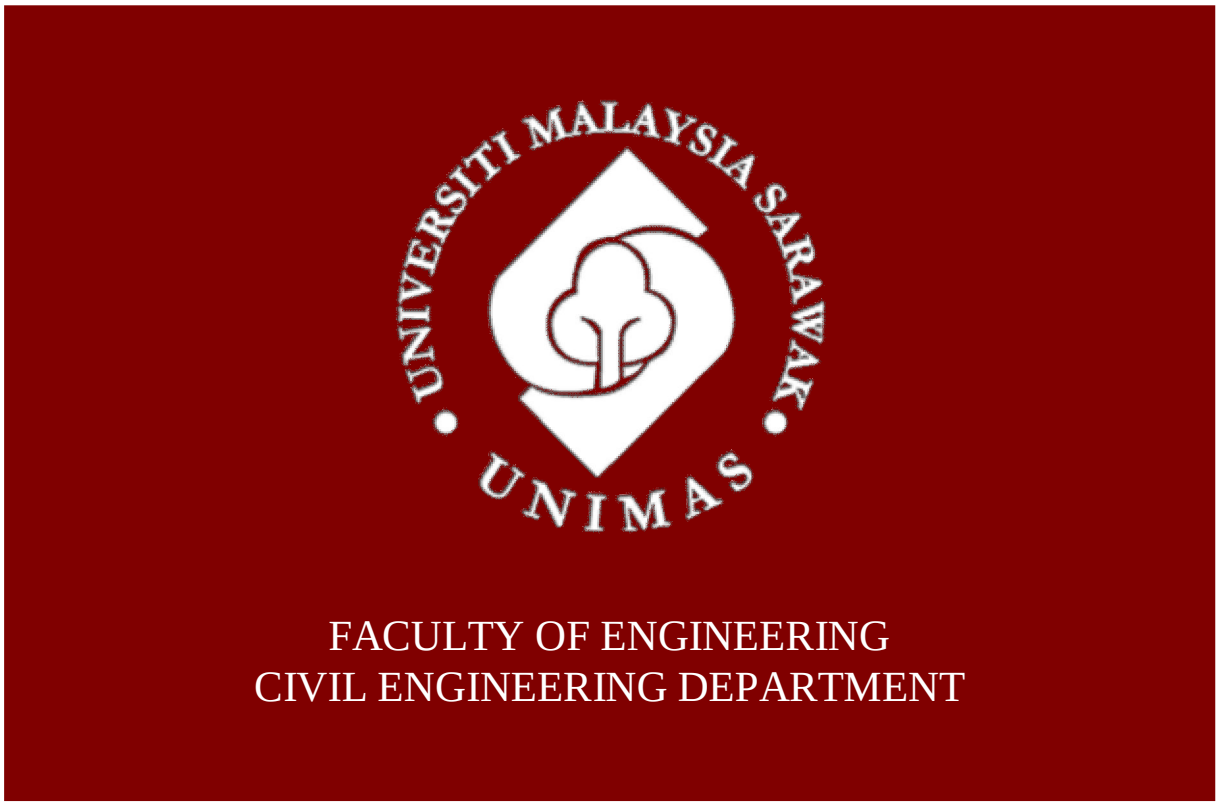


FACULTY OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT

# DURABILITY CONSIDERATION OF FOAMED CONCRETE

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**Degree of Bachelor**
**(Civil Engineering)**
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**BORANG PENGESAHAN STATUS TESIS**

Judul: **DURABILITY CONSIDERATION OF FOAMED CONCRETE**

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# DURABILITY CONSIDERATION OF FOAMED CONCRETE

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A report submitted in partial fulfillment

of the requirements for the award of the

degree of Bachelor of Civil Engineering

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April 2009

"I declare that this project report entitled "DURABILITY CONSIDERATION OF FOAMED CONCRETE" is the result of my own research except as cited in the references"

Signature : ……..

Name : TAN KHAR ENG

Date :

*Dedicate to my beloved parents, friends and supervisor*

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## ABSTRACT

Foamed concrete is a concrete which contains a lot of artificial pore distributed throughout the mass of concrete. The main purpose of the artificial pores is to reduce the density and weight of concrete. This study is mainly focused on water absorption and capillary sorption which two main factors are influencing the durability of foamed concrete. Durability of concrete is the ability to resist the deterioration process. Several mix proportions were applied to produce the tested specimens; specimens from low density (730 $kg/m^3$) to moderate density (1270 $kg/m^3$) and specimens with and without replacement of sand by fly ash are considered. The tests showed that low density foamed concrete absorbed more water. For the same density, specimens containing fly ash absorbed less water for both water absorption and capillary sorption. Capillary sorption test showed that artificial pores contributed in the capillary action to take in water. Compare to capillary sorption, water absorption is higher because of the larger surface contact between water and concrete surface. Foamed concretes with 28 days of age showed that increasing in ingredient of fly ash in the mixtures reduced its compressive strength.

# ABSTRAK

Konkrit berbuih merupakan konkrit yang mengandungi sfera kosong yang bertaburan di dalam konkrit. Tujuan utama sfera kosong ini adalah untuk mengurangkan ketumpatan dan berat konkrit. Dalam kajian ini, tumpuan telah diberikan kepada penyerapan air dan serapan kapilari yang merupakan dua factor utama menjejaskan kekuatan konkrit bebuih. ketahanan konkrit merupakan kebolehan konkrit melambatkan atau melembabkan proses kerosakan atasnya. Beberapa jenis campuran telah digunakan untuk menghasilkan sampel kajian; daripada ketumpatan rendah (730 kg/$m^3$) ke ketumpatan sedeharna tinggi (1270 kg/$m^3$) dan sampel yang mengandungi dan juga sampel yang tidak mengandungi habuk arang. Kajian menunjukan sampel yang berketumpatan rendah menyerap lebih banyak air dan pada ketumpatan sama, sampel bercampuran habuk arang menyerap kurang air di dalam ujian penyerapan air dan serapan kapilari. Ujian serapan kapilari juga menunjukan sfera kosong telibat dalam tindakan kapilari untuk menyerap air. Berbanding dengan serapan kapilari, kadar serapan konkrit berbuih di ujian penyerapan air lebih tinggi disebabkan oleh keluasan sentuhan antara permukaan konkrit berbuih dengan air di ujian penyerapan air lebih besar. Konkrit berbuih yang berusir 28 hari menunjukan, perningkatan kandungan habuk arang di dalam konkrit berbuih akan melemahkan kekuatannya.

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# LIST OF ABBREVIATIONS AND NOTATIONS

| | |
|---|---|
| CS | - Foamed concrete contain cement-sand |
| CSF | - Foamed concrete contain cement-sand-fly ash |
| CF | - Foamed concrete contain cement-fly ash |
| *WA* | - Water absorption test |
| *CAP* | - Capillary sorption test |
| *C* | - Compressive strength test |
| m | - Meter |
| kg | - Kilogram |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Foam concrete is a type of lightweight concrete which contains a lot of artificial pores distributed throughout the mass of concrete and usually contain not less than 25% of air content (in volume). This lightweight material consist Portland cement, water, fine sand or/and fly ash and homogeneous void structure created by introducing air in form of bubbles.

Generally, introduce air (pre-formed foam) into a concrete mix to form foamed concrete is using two principal methods. First method is mixing preformed foam from a foam generator with other constituents and the second method is mixing a synthetic or protein based foam with the other constituents.

The characteristics of foamed concrete are depending on the mix design; however most of the foamed concretes consist of the following properties:

- It is lightweight compare to conventional concrete
- Low coefficient of permeability
- Low water absorption

- Good freeze/thaw resistance
- High modulus of elasticity
- A rigid well-bonded body
- High workability
- Shock absorbing qualities
- Thermal and sound insulation.

### 1.1.1 Strength criteria

Compressive strength always is the first consideration for concrete no matter it is conventional concrete or foamed concrete because compressive strength plays an important role in sustaining load. In normal concrete, the greater the amount of air content the weaker the material, so it is not surprising that the lower the density or higher in foamed content is tend to produce concrete with lower strength.

### 1.1.2 Durability

In addition to its ability to sustain load, concrete is also required to be durable during its service life. Durability of concrete is the ability of concrete to resist the deterioration processes. Sorptivity and permeability are two main factors leading to the deterioration processes such as ingress aggressive fluids from the ambient environment into concrete, followed by chemical and physical harming the concrete fabric or reinforcement. Consequently, sorptivity and permeability of concretes will be the two main factors to control the durability of concretes.

## 1.2 Problem statement

Nowadays, application of lightweight concrete in construction is common. Therefore, the understanding the properties of lightweight concrete is important. Generally, sorptivity and permeability are considered as the main factors influencing the durability of concrete. Artificial air voids and density of foamed concrete have the significant effect on the sorption behaviour and as well as the strength of foamed concrete. Consequently, an understanding to the effect of artificial foam on the durability of foamed concrete is important to the service life as a building construction material.

## 1.3 Research objective

The objectives of this research work are:

a) To identify appropriate mix proportions to have a suitable light weight foam concrete.
b) To identify appropriate mixing method to get suitable consistency for fresh foam concrete.
c) To study the durability characteristics of selected foam concretes.

## 1.4 Project outline

The report consists of five chapters. The first chapter is the introduction to the research objective. The second chapter includes the literature review of the water absorption and sorption behaviour of foamed concrete and some relevant outcomes of other researchers. The third chapter includes the method and process of preparing the specimens and the experimental setup to be employed in this research program. Fourth chapter is expected to be of the results of the research which includes detail data of the tests and analysis. The last chapter includes the discussion and conclusion of the test results.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Durability

The durability of concrete can be defined as its resistance to deterioration process that may occur when interaction with its environment (external), or between the constituent materials or their reaction with contaminants present (internal). As a result, damage may be happen by corrosion of embedded steel reinforcement leading to the breakdown of the surrounding concrete (Neil Jackson and Ravindra K. Dhir, 1996).

Permeation is one of the processes mainly leading to the deterioration of concrete by ingress aggressive liquid into concrete from the surrounding environment and following by physical and chemical processes attack the concrete reinforcement. Moisture movement is also caused the damage occurring internally within concrete. Permeation comprises process of absorption and permeability. Both of the processes are mainly affected the durability (service life) of concrete, ability of concrete to retard or limit these processes significantly influence the durability and rate of deterioration (Neil Jackson and Ravindra K. Dhir, 1996).

## 2.2 Absorption and Permeability

Absorption is the process of concrete suck or takes in a liquid by capillary attraction. Absorptivity or sorptivity is the rate of liquid absorbs into concrete and mainly depends on the total volume of capillary pores, interconnection among the pores and the moisture gradient on the surface (Kunhanandan Nambiar and Ramamuthy, 2007).

Permeability is the flow of water under pressure in a saturated porous medium. This property depends on the ambient pressure differential and the size and the interconnection of the capillary pores (Kunhanandan Nambiar and Ramamuthy, 2007).

Measurement of permeability of concrete only suitable for structures immerse in water e.g. water retaining structures and the mechanism of ingress water into concrete will be happen under a head of water, but for the other structures (on ground), concrete is rarely saturated while in use, so absorptivity is another parameter to explain the moisture movement of concrete (Hall and Yau, 1987). Clearly, an understanding of moisture movement in concrete is important to estimate their durability (service life).

## 2.3 Water absorption behaviour

A water absorption behaviour test for foamed concretes was tested by Kunhanandan Namiar and Ramamurthy.

The materials used are;

i. Ordinary Portland cement conforming to IS 12269-1987
ii. Pulverized river sand finder than 300 microns (specific gravity = 2.52)
iii. Class F fly Ash (specific gravity = 2.09)
iv. Foam produced by aerating an organic based foaming agent (dilution ratio 1:5 by weight and density is 40 kg/$m^3$)

The mix proportions of all foam concrete mixes reported are given in Table 2.1. The specimens used in this test were in size of 50 mm. Three cube specimens were cast for each mix of foam concrete which had been moist-cured for 7, 28 and 90 days. The specimens were dried to constant mass, than immersing in water and measuring the increase in mass as a percentage of dry mass in regular interval. (Kunhanandan Nambiar and Ramamurthy, 2007)

**Table 2.1:** Composition of mixtures with filler – cement ratio of 2 (Kunhanandan Nambiar and Ramamurthy, 2007)

| Mixture No | FA (%) | FV (%) | Composition of mixture per $m^3$ | | | | | Fresh density $kg/m^3$ | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Cement (kg) | Sand (kg) | Fly ash (kg) | Water (kg) | Foam volume ($m^3$) | Theoretical | Measured |
| 1 | 0 | 10 | 438 | 876 | 0 | 412 | 0.1 | 1731 | 1753 |
| 2 | 0 | 20 | 385 | 771 | 0 | 371 | 0.2 | 1535 | 1546 |
| 3 | 0 | 30 | 332 | 665 | 0 | 330 | 0.3 | 1339 | 1339 |
| 4 | 0 | 40 | 279 | 558 | 0 | 289 | 0.4 | 1142 | 1132 |
| 5 | 0 | 50 | 225 | 451 | 0 | 249 | 0.5 | 945 | 952 |
| 6 | 20 | 10 | 418 | 669 | 167 | 421 | 0.1 | 1679 | 1682 |
| 7 | 20 | 20 | 368 | 588 | 147 | 379 | 0.2 | 1490 | 1513 |
| 8 | 20 | 30 | 317 | 508 | 127 | 336 | 0.3 | 1300 | 1321 |
| 9 | 20 | 40 | 266 | 426 | 107 | 295 | 0.4 | 1110 | 1106 |
| 10 | 20 | 50 | 215 | 344 | 86 | 254 | 0.5 | 918 | 889 |
| 11 | 40 | 10 | 399 | 479 | 319 | 430 | 0.1 | 1630 | 1629 |
| 12 | 40 | 20 | 351 | 421 | 281 | 387 | 0.2 | 1447 | 1469 |
| 13 | 40 | 30 | 303 | 363 | 242 | 343 | 0.3 | 1263 | 1286 |
| 14 | 40 | 40 | 254 | 305 | 203 | 301 | 0.4 | 1079 | 1080 |
| 15 | 40 | 50 | 204 | 245 | 163 | 259 | 0.5 | 892 | 925 |
| 16 | 60 | 10 | 380 | 304 | 456 | 439 | 0.1 | 1584 | 1577 |
| 17 | 60 | 20 | 335 | 268 | 401 | 395 | 0.2 | 1406 | 1425 |
| 18 | 60 | 30 | 288 | 231 | 346 | 351 | 0.3 | 1228 | 1251 |
| 19 | 60 | 40 | 242 | 193 | 290 | 308 | 0.4 | 1048 | 1054 |
| 20 | 60 | 50 | 194 | 155 | 232 | 266 | 0.5 | 866 | 898 |
| 21 | 80 | 10 | 363 | 145 | 580 | 449 | 0.1 | 1541 | 1524 |
| 22 | 80 | 20 | 319 | 127 | 510 | 404 | 0.2 | 1368 | 1382 |
| 23 | 80 | 30 | 274 | 110 | 439 | 359 | 0.3 | 1194 | 1216 |
| 24 | 80 | 40 | 229 | 92 | 367 | 315 | 0.4 | 1018 | 1028 |
| 25 | 80 | 50 | 182 | 73 | 292 | 273 | 0.5 | 840 | 817 |
| 26 | 100 | 10 | 345 | 0 | 691 | 459 | 0.1 | 1499 | 1472 |
| 27 | 100 | 20 | 303 | 0 | 607 | 413 | 0.2 | 1331 | 1338 |
| 28 | 100 | 30 | 260 | 0 | 521 | 368 | 0.3 | 1161 | 1181 |
| 29 | 100 | 40 | 217 | 0 | 433 | 323 | 0.4 | 989 | 1002 |
| 30 | 100 | 50 | 171 | 0 | 342 | 282 | 0.5 | 814 | 840 |

### 2.3.1 Effect of foam volume on water absorption

For a given volume of foam concrete, water absorption of foam concrete reduce proportionally to the reduction in density of concrete or increase in the foam volume. Figure 2.1 (a) and (b) show the variation in water absorption of foam concrete with time, respectively for cement-sand and cement-sand-fly ash mixes (Kunhanandan Nambiar and Ramamurthy, 2007). From the graph we can observe that the water absorption for every matrix increases for the first two days, then decreases gradually and becomes almost constant within 7 days. The important information from the Figure 2.1 is the water absorption of foam concrete reduces