SHRINKAGE DEFORMATION OF DIFFERENT SHAPE OF FOAMED CONCRETE SPECIMEN

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ABSTRACT

In construction field, the most important element is concrete. Majority of construction in Malaysia use the concrete and the improvement of concrete technology is very important. Example of concrete technology improvement is foamed concrete. Foamed concrete is additional of foaming agent in the concrete mixture to control the concrete density and the foamed concrete do not used the course aggregate. The foaming agent used to trap the air to reduce the concrete density. The strength of foamed concrete is lower than normal concrete and it is suitable to be used at the uncritical structure in the construction. The foamed agent also expose to crack effected by drying shrinkage. Some of the factors causes the drying shrinkage are investigated. Two factors of drying shrinkage investigated in this study are different density of foamed concrete and different shapes of concrete specimens. Prism sized 100mm x 100mm x 500mm, cylinder sized 150mm Ø x 300mm and 150mm cube for 1200 kg/m^3 and 1600 kg/m^3 density were produced throughout this experiment. The uses of prism and cylinder specimens are because it is normal shape of concrete structure with different surface expose to environmental for shrinkage observation. The cube was used for compressive strength test to prove the targeted density. The result of compressive strength test shows the increments of concrete density produced high strength of concrete. On the other hand, the increments of concrete density reduce the shrinkage value as well as the reduction of surface exposes to the environmental.

ABSTRAK

Dalam bidang pembinaan, bahagian yang paling penting ialah konkrit. Majoriti pembinaan di Malaysia mengunakan konkrit dan peningkatan teknologi konkrit sangat penting. Contoh peningkatan teknologi konkrit ialah Konkrit Buih. Konkrit Buih adalah konkrit yang campurannya ditambah dengan agen buih untuk mengawal ketumpatannya dan tidak menggunakan batu baur kasar dalam campurannya. Agen buih dalam campuran konkrit tersebut adalah bertujuan untuk memerangkap udara untuk mengurangkan ketumpatannya. Kekuatan Konkrit Buih adalah lebih rendah berbanding konkrit biasa dan hanya sesuai digunakan pada struktur yang tidak kritikal dalam pembinaan. Konkrit Buih terdedah kepada keretakan yang dipengaruhi pengecutan konkrit disebabkan kekeringan. Beberapa faktor yang menyebabkan pengecutan konkrit disebabkan kekeringan telah disiasat. Dua factor yang menyebabkan pengecutan konkrit disebabkan kekeringan adalah perbezaan ketumpatan konkrit dan perbezaan bentuk konkrit. Prisma bersaiz 100mm x 100mm x 500mm, silinder bersaiz 150mmØ x 300mm dan kiub 150mm digunakan untuk ketumpatan 1200 kg/m^3 dan 1600 kg/m^3 sepanjang eksperimen dijalankan. Penggunaan bentuk prisma dan silinder adalah kerana ia adalah bentuk struktur konkrit yang biasa digunakan dengan luas permukaan terdedah yang berbeza untuk pemerhatian pengecutan. Manakala konkrit berbentuk kiub adalah untuk ujian mampatan. Keputusan ujian mampatan menunjukkan konkrit yang ketumpatan tinggi menghasilkan kekuatan yang tinggi. Sebaliknya keputusan bacaan pengecutan konkrit menunjukkan peningkatan ketumpatan konkrit akan mengurangkan nilai pengecutan sejajar dengan pengurangan luas permukaan yang terdedah.

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LIST OF SYMBOLS

ε	=	Strain
$\emptyset$	=	Diameter
L	=	Length
B	=	Width
H	=	Depth

LIST OF ABBREVIATIONS

ASTM	=	America Society for Testing and Materials
BS	=	British Standard
(W/C) Ratio	=	Water Cement Ratio
(S/C) Ratio	=	Sand Cement Ratio
OPC	=	Ordinary Portland Cement

CHAPTER 1

INTRODUCTION

1.1 Background of Study

In this time, concrete are extensively used in developing country to construct the building. Major element in construction of any building is concrete. Construction industry is not complete without element of concrete. In this case, the improvement of concrete technology is very important to ensure the constructed buildings are strong and safe to be used especially in high rise building.

Example of improvement of concrete technology is adding the foam agent to the concrete mixture to reduce the density of concrete. It's called foamed concrete. Foamed concrete is lightweight concrete used at uncritical structure because it can resist small load compared with normal concrete. Foamed concrete do not use coarse aggregate, but only used the fine aggregate in the concrete mixture. Thus the strength of foamed concrete is lower than normal concrete. The characteristic of this concrete is high compressive strength, durability, versability and easy to get in whole country but the concrete is low tensile strength and can crack when over loading. Besides that, the concrete also can crack effected by shrinkage.

Shrinkage is long term deformation of concrete and occurs small volume in concrete. The main factor occurrence of shrinkage is loss of water. Water needed in concrete mix more than uses of cement hydration. The other factors are type of aggregate, curing, relative humidity and concrete mixture. To ensure the strength of concrete is consistence, the prediction of concrete shrinkage must be done.

1.2 Problem Statement

The cracks of concrete affected by shrinkage are normally occurring in concrete. The crack occurs on the surface of concrete. Hardened concrete has capillaries. So, this capillary filled by water. At the same time, the water absorbed on the surface of particles.

So, this concrete exposed to drying shrinkage situation. This situation occur when the water in that capillary of concrete evaporates then, the concrete continues to shrink. This situation effected by speed of evaporation, porosity on concrete, environment, temperature and relative humidity. If the concrete soaked water in the capillary and that water evaporate again, the concrete is also shrinking again.

The majority of drying shrinkage occurs within few weeks after casting concrete. Normally, to ensure the concrete is free from shrinkage, the concrete must be restrained. In this situation means, something prevents the concrete from shortening in any direction. This study conducted to know the rate of concrete shrinkage affected by different density of foamed concrete and the shape of specimen.

1.3 Objective of Study

i. To determine the rate of shrinkage affected by different density of foamed concrete.

ii. To investigate the relationship between rate of shrinkage with different shape of specimens.

1.4 Scope of Study

In this study, the densities of foamed concrete used are 1200 and 1600 kg/m^3. The sand-cement ratio is 1:2 for all the mixture.

This specimen tested at seven and 28 days after casting. For this study, two types of shape will be used are:

- Prism shape (100mm x 100mm x 500mm).
- Cylinder shape (150mm x 300mm).

1.5 Significant of Study

This study is important to know the consistency strength of foamed concrete in long term. After knowing the rate of shrinkage in different density of concrete and in different shape of specimen, the strength of concrete in long term can be estimated. The increment of shrinkage can decrease the strength of concrete. The shrinkage of concrete is occurring every time when the concrete soaked the water and then that water evaporate. So, its mean the shrinkage of concrete occur continuously even in small volume.

Example situation is outdoor concrete column. When the location of column at outdoor mean the column expose to weather condition. When the rain season, the concrete column soaks the water and then when the dry season, the soaked water in the concrete column evaporate and the shrinkage occur to that column. This situation show the shrinkage of concrete continuously occurs. Although the volume of shrinkage is small, it is still can affect the strength of concrete in long term.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The using of concrete is very extensive in construction field. The strength of concrete is the main factor to maintain durability of these building because normally the structure of building using the concrete. The example is structure beam, column and basement. The strength of concrete is affected by the specification of material used in concrete mixture. Because of the extensive use of concrete in the world, the new technologies of concrete to improve their strength are very important. One example of new technology in concrete construction is foamed concrete. Foamed concrete also called lightweight concrete. The foamed concrete is different with normal concrete because this concrete does not use the coarse aggregate and this concrete using the foaming agent. The strength of the foamed concrete is lower than normal concrete so it capable to carry small loading only. The foamed concrete is suitable to be used at uncritical structure because the strength is low. To control the strength of foamed concrete, the material ratio of concrete mixture and as well as shrinkage must be considered. This chapter are purpose to find the sources about shrinkage of concrete in different density and different shape.

2.2 Concrete Material

Concrete is the combination of three (3) main components such as cement, aggregate and water with specific ratio. The strength of concrete depends on the ratio of material used in concrete mixture. For example is water/cement ratio. In the mixture, the aggregate normally divided by two types such as fine aggregate and coarse aggregate. The coarse aggregate is a material to support load and also the important material to control the strength of the concrete. Fine aggregate is a filler to fulfill the empty space between coarse aggregate.

This important to increase the density of concrete and also increase the strength of concrete. The water as a agent to hydrate the cement to bind all component of concrete to make hardened concrete. The ratio of water must be calculated carefully because quantity of water also gives the effect on the concrete strength. Cement as a binding agent. It's important to bond all component of concrete to make hardened concrete. The amounts of cement use for the concrete mixture are must be calculate carefully because it does also can give the effect to the strength of concrete.

In concrete, the strength effected by two factor such as the water/cement (W/C) ratio and the compaction of concrete. The compaction of concrete is important to ensure no air void in concrete because the air void also can affect the strength of the concrete (Neville, 1995).

2.2.1 Cement

Cement is the agent to bind all components in concrete mixture such as fine aggregate and coarse aggregate. The normal cement use Ordinary Portland Cement (OPC). The cement reacts with water. Presence of water in concrete mixture can hydrate the silicate and aluminates in cement content. It's can cause the hydration of cement and make a hardened concrete in time period (Neville, 1995). Table 2.1 shows the compound of Portland cement and Table 2.2 shows the Chemical Composition and Properties of Ordinary Portland Cement.

Table 2.1: Main Compound of Portland Cement (Neville, 1995).

Compound	Oxide Composition
Trikalsium Silikat (C_3S)	$3CaO.SiO_2$
Dikalsium Silikat (C_2S)	$2CaO.SiO_2$
Trikalsium Aluminat (C_3A)	$3CaO.Al_2O_3$
Tetrakalsium Aluminoferit (C_4AF)	$4CaO.Al_2O_3.Fe_2O_3$

Table 2.2: Chemical Composition and Properties of Ordinary Portland Cement (Cabrera and Al-Hasan, 1997).

Oxide Composition	**%**	**Mineral Composition**	**%**
CaO	64.81	C_3S	57.8
SiO_2	20.96	C_2S	16.91
Al_2O_3	5.04	C_4AF	10.00
Fe_2O_3	3.29	C_3A	7.8
SO_3	3.00	Specific Surface, m^2/g	0.359
MgO	2.44	Specific Gravity	3.20
K_2O	0.78	Setting Time-Initial,mins	165
Na_2O	0.32	Final, mins	230
Loss of ignition	0.84		

2.2.2 Water

Water in concrete mixture is important as component to hydrate the cement and make a hardened concrete. In concrete mixture must be use the clean water and do not have a chemical that can affect the hydration of cement and also effect the strength of concrete. The amount of water in concrete mixture also must be calculated carefully because the ratio of water/cement is one of important element to control the strength of concrete (Neville, 1995).

The water dosage can affect the workability of fresh concrete. The increment of water dosage in concrete mixture can increase the workability of fresh concrete. The workability of fresh concrete can determine by slump test. In slump test, the deformation of cone concrete caused by gravity. The shear stress is increased with the depth beginning from the top of the slump cone. Normally, the shear stress and velocity of the deformation will produce near the bottom of the slump cone. The normal concrete water dosage also depends on maximum grain size of the coarse aggregate (Lijiu and Hongmei , 2001).

2.2.3 Coarse Aggregate

In concrete mixture, the most important element is aggregate because the aggregate use to support the load in concrete. That's why the volume of aggregate is the highest volume in concrete mixture. The aggregate is the main factor to control the strength of hardened concrete and also to control the workability of fresh concrete. At least three-quarters of the volume of concrete is occupied by aggregates and hence it is not surprising to know that is quality is of considerable importance (Neville, 1995). Besides that, the aggregate is important to control the concrete shrinkage and the strength of aggregate influenced by the particles shape of the aggregate and the quality of aggregate.

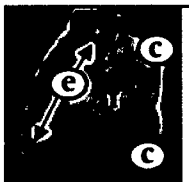
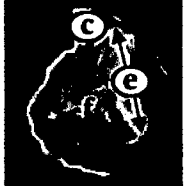
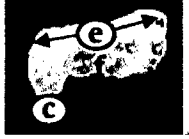
2.2.3.1 Particles Shape of Aggregate

The quality of fresh and hardened concrete are influenced by shape of aggregate particles and the shape of aggregate particles influence by nature and degree of stratification of rock deposit, the type of crushing plant used and the size of reduction ratio. This factor is ability to produce the high strength concrete with good bonding characteristics at also at the same time maintaining the workability of the fresh concrete (Rajeswari, 2004). Besides that, the improvement in shape of aggregates also to be a major factor in reduction of the water to cement ratio needed to produce a concrete mixture. At the same time, the high quality of aggregate also has the ability to decrease the cost of production a concrete (Hudson, 1996).

The best characteristics of aggregate such as more cubical and equidimensional in shape with better surface texture and ideal grading can increase the strength of concrete and enhancing the quality of concrete. The optimum orientation and packing of high quality shape of aggregate particles such as cubical and angular and the poor quality shape of aggregate particles such as irregular, elongated and flaky. The shape of aggregate such as cubical and angular is classified the good characteristics of aggregate because it's can produce the high density and high strength of concrete and the shape of aggregate such as flat or elongated classifies as poor quality of aggregate because the particles can decrease the workability of fresh concrete, reduce the bulk mass and consequently decrease the compressive strength of concrete. The using of poor quality of aggregate also increase the requirement of sand, cement and water in concrete mixture.

Rajeswari (2003) stated that, the standard techniques to classify the shape, size grading and surface texture of aggregate is using the British Standards, America Society for Testing and Materials (ASTM) and New Zealand Standards as shown in Table 2.3.

Table 2.3: Typical Shaped Particles for the Range in the Number of Faces (f), Edges (e) and Corners (c) (Rajeswari, 2003).

Micrographs	Typical shapes	No. of faces (f)	No. of edges (e)	No. of corners (c)
	Cubical	5–6	11–12	7–8
	Angular	4–8	6–14	6–12
	Irregular	3–5	4–10	4–9
	Flaky	2–6	3–9	3–8
	Elongated	3–6	4–9	4–8
	Flaky & Elongated	2–5	3–9	3–8

2.2.3.2 Aggregate Strength

Concrete is one material which has high compressive strength but low tensile strength. The shape of aggregate can influence the strength of concrete. These occur in aspect arrangement of particles. The aggregate obviously cannot transmit a tensile force from one particle to another. The cement agent combines with particles to form a mass which can resist a small amount of tension. It's also may appear that particles transmit compressive force from one to another and increase the strength of concrete. In term arrangement of particles, the flat surfaces of aggregate were piled vertically and a compressive force could be transmitted through the pile such as stone structural column but this is not a practical arrangement because normally in concrete mixture using the random arrangement.

Figure 2.1 show the arrangement vertically of flat surface of aggregate. Aggregate piled to transmit a compressive force. But this not a practical arrangement. Normally, when the arrangement of aggregate is random, the particles are haphazard neatly such as the figure 2.1. The figure show a cross section through a container of aggregate with concentrated weight or force acting downward on one particles of aggregate. The concentrated load is necessarily transmitted to more particles as the force is transmitted deeper into the container and thereby is spread over most of the bottom of the container (Marotta, 2005).