TIME-DEPENDENT DEFORMATION OF FOAMED CONCRETE WITH DIFFERENT DENSITY.

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ABSTRAK

Konkrit berbuih merupakan sejenis konkrit yang tidak asing pada masa sekarang. Penggunaan konkrit berbuih semakin banyak diaplikasikan khususnya didalam bidang pembinaan. Dengan penggunaan konkrit berbuih, ia dapat menggantikan konkrit biasa pada tempat-tempat yang berpotensi seperti dinding dan sebagainya. Penyelidikan ini berdasarkan pada sifat konkrit berbuih. Dimalaysia, masih kurang lagi data-data yang berkaitan dengan sifat konkrit berbuih tersebut. Ini penting bagi mengenalpasti sejauh mana sifat konkrit berbuih tersebut. Dengan ujian yang dijalankan, ia dapat membantu untuk mengenal pasti dan dapat menjangkakan sifat konkrit berbuih ini pada masa hadapan terutama dari segi kelakuan ubahbentuk bersandar masa. Untuk penyelidikan ini, konkrit berbuih disediakan pada dua ketumpatan iaitu ketumpatan 1200 kg/m^3 dan ketumpatan 1600 kg / m^3 dan diuji dengan ujian ketumpatan, ujian pengecutan, ujian rayapan dan ujian modulus elastik. Keputusan ujian dibandingkan dengan berketumpatan yang berbeza. Keputusan ujian menunjukkan konkrit berbuih berketumpatan tinggi mempunyai kekuatan lebih tinggi berbanding dengan konkrit berbuih yang berketumpatan rendah. Perbandingan nilai elastik modulus diantara konkrit berketumpatan 1200 kg/m^3 dan konkrit berketumpatan 1600 kg / m^3 ialah 42.38 peratus. Ujian rayapan menunjukan pemendekan berlaku sepanjang masa. Pada peringkat permulaan, proses pemendekan berlaku dengan tinggi dalam masa yang singkat dan semakin lama semakin sekata. Keputusan ujian pada hari yang ketujuh menunjukkan nilai rayapan ialah 1233.67 x 10^{-6}. Pada akhir penyelidikan dapat diperhatikan penggunaan konkrit berbuih berketumpatan 1200 kg/ m^3 dipengaruhi oleh pemendekan jangka masa panjang dan pemendekkan ini sentiasa berlaku.

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Ø	-	Specimen Diameter.
$C(t,to)$	-	Creep compliance or specific creep
$\varepsilon s_h\ (t)$	-	Shrinkage strain at time t (micron)
ε_{el}	-	Instantaneous elastic strain at time, t_0
ε_t	-	Strain of loaded specimen at time, t_0
t	-	Time
t_o	-	Initial time at the beginning of loading or drying

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Concrete is an any product or mass made by the use of a cementing medium. Generally, this medium is the product of reaction between hydraulic cement and water. Now days, concrete is made with several types of cement and also containing admixtures such as fly ash, slag, polymers and so on. Concrete also can be prepared with many method such as heated, steam-cured, extruded, sprayed and so on (Neville and Brooks,1987).

Foam concrete can be known as cement paste or mortar, referred to their characteristic it can be classified as lightweight concrete. The weight of the foamed concrete more light than the normal concrete but the strength of the concrete was less than the foamed concrete. Foamed concrete consist from some material such as fine aggregate, cement, water and foaming agent. The application of the foamed concrete can be obtained to structural, partition, insulation and filling grades (Narayanan and Rammamurthy, 2008).

Creep of concrete is the continuous deformation with time, which takes place under conditions of sustained loading. There are many factors that influenced to the creep in concrete, for example it increases with water/cement ratio and decrease with increase relative humidity. The effect of creep of concrete is not often considered directly in reinforced concrete design. However, it is taken into account when calculating deflection. The modulus elasticity is an important factor in the design of most concrete structures. The modulus is used for calculation of deformation, deflection or stresses under normal working load. Some factor that influencing to elastic modulus are cement content, age and reduction of water/cement. It will increase when the factor increase. The modulus of elasticity of structural lightweight concrete is generally 20 per cent to 50 per cent lower than for normal-weight concrete of equal strength (Surahyo, 2002).

1.2 Problem Statement

Normal concrete will contain more material other than the foamed concrete. Materials that contain in the normal concrete are course aggregate, fine aggregate, cement and water. With the course aggregate involved as a material, the load of the concrete will be increase. Increasing load from the upper structure will influence the lower structure. Besides that it will implicate the quantity of the concrete and the cost. Different with the foamed concrete, utilisation of the light material will be selected such as fine aggregate, cement, water and foaming agent. The cost when using the normal concrete and foamed concrete will be different.

The study was conducted to know the value of the creep and modulus elasticity of foamed concrete. Creep is an important factor need to be considered in concrete development because it will affect the strength of the concrete. The tensile strength of the concrete will decrease and the problems may cause cracking to the concrete structure. Cracks formed already in the plastic stage of the material are the cause of numerous structural faults and may requires expensive repair measures. Besides that, creep also will decrease the durability of the concrete.

In Malaysia, there are no specific data collection about the values of creep and modulus elasticity of foamed concrete. The application of this study will investigate the values of creep values and modulus elasticity of foamed concrete. Therefore this study was performed to make a comparison of time-dependent deformation in terms of creep and modulus elasticity with different densities.

1.3 Objectives of Study

The objectives of this study are:

i. To investigate the values of creep and modulus of elasticity of foamed concrete
ii. To compare the values of creep and modulus of elasticity of foamed concrete of 1200 kg/m^3 and 1600 kg/m^3 density.

1.4 Scope of Study

The scope of this study will follow the objectives and the limitation of the densities that will be carried out for this study which are 1200 kg/m^3 and 1400 kg/m^3. The test will performed after the curing process at the age of 28 days. Other scopes are:

i. Use the cylindrical specimens with dimension 150 mm diameter x 300 mm height for creep and elastic modulus testing.
ii. The mix proportion for the sand-cement ratio (S/C) equal to 1:2.
iii. The testing will be carried out according to:

- ASTM C 192 / C 192 M – 05 Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
- ASTM C 512 – 02 Standard Test for Creep of Concrete in Compression.
- ASTM C 39 / C 39 M – 04a Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- ASTM C 469 – 02 Standard Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Now days, concrete is very important in construction. Every building in the world are using the same material which is concrete. So that it is important to us to know the workability and the factor that will affect the concrete. Concrete can be defined as a mixture that contains cement, aggregates and water. For some purpose, concrete can be added by the admixture.

Concrete used is the best selection because of their strength and durability. But its our reasonability to know what are their disadvantages to avoid future problems. With the some methods, good concrete can be provided. There are two overall criteria that influence the concrete which is it has to be satisfactory in its hardened state and also in its fresh state while being transported from the mixer and placed in the formwork. Other factor that will influencing concrete strength is compressive strength, that many properties of concrete are related which is density, impermeability, durability, resistance to abrasion, resistance to impact, tensile strength and resistance to sulphates (Neville & Brooks, 1987).

2.2 Concrete Materials

Concrete can be produced by three basis components which is cement, water and aggregates. The important thing to know is how to determine the ratio of the composition when produced a good concrete. For the reasons to produce good concrete is long term used when the material are mixed together. If the design of structure are safe to used, there are no use if the production of the material cannot be fulfill the specification needed. So that there are important the basis of the concrete production with the material used to produce good result in terms of time.

With the experience and innovation from the older researcher, concrete can be improved with some mixing method with added admixture to the concrete depends on their purpose of the concrete used. Sometimes the admixture are not used because of the environment factor, without admixture, concrete can be produced with mixing the three basis material. There are some factor could be a factor to the strength of concrete which is ratio between cement and water, ratio between cement and aggregate, grading of the surface texture, shape and strength of the aggregate and maximum size of the aggregate.

The importance of concrete properties can be expressed as what is the purpose of the designing effective mixing concrete. Designer must know how to design concrete mixing in terms of their durability and concrete properties depends on their types of site, place and transport the concrete to the construction site. With these two elements, the engineer can determine the mixing to take count what will be happen to the construction site. This mixing design can be explained as process that choose suitable material to achieve the objective and economic producing with minimum properties requirements such as strong and can sustain in long time period.

2.2.1 Aggregate

Aggregate have particles of random shape and they can be found in nature as sand, gravel, stones or rock that can be crushed into particles. Aggregate also can be defined as mineral particles which have rock as their origin unless otherwise specified. Aggregate is a component from the three basis material to produce concrete. There are 75 per cent of concrete volume is aggregate. Because of that selecting good aggregate must be considered. Good concrete must from the good aggregate, if the aggregate in low grade the concrete also in a low grade. It is important to us to know their strength and durability to make sure the aggregate will give best result of concrete production (Theodore, 2005).

In the financial scope, aggregate are more economic than cement, so that there are more economic if the aggregate used are more compared to cement used. But, economical are not the important part need to be considered, there are more important aspect need to be looking for which is their stabilization and high durability of volume in terms of concrete technique

Aggregates can be divided into two types which are coarse aggregate and fine aggregate. There are many size of aggregates, vary sizes from several inches to the size of the smallest grain of sand. In special cases aggregate larger than several inches may be used. A good concrete production must considered the ratio of aggregates sizing. In some cases these small particles are deliberately mixed with aggregate and are then considered as an addictive. To determine the size and class of aggregate, sieve analysis test can be operated. Sieve analysis test can separate the size of aggregates depends on their shape and size. Opening of the size from the sieve number will determine the formation of the sieve, from large opening to small opening (from 125mm to 38μm) (Theodore, 2005).

Table 2.1: Sieve Sizes and Composition (Theodore, 2005)

Sieve Designation		Nominal Opening (in)
75 mm	3 in	3.0
37.5 mm	$1^{1/2}$ in	1.5
19.0 mm	¾ in	0.75
12.5 mm	½ in	0.5
6.3 mm	¼ in	0.25
4.76 mm	No.4 in	0.187
2.36 mm	No.8 in	0.0937
1.18mm	No.16 in	0.0469
0.6 mm	No.30 in	0.0234
0.3 mm	No.50 in	0.0117
0.15 mm	No.100 in	0.0059
0.074	No.200 in	0.0029

There are three types of component that will effect the aggregate which is the organic composition that will disturb the hydration to cement, the aggregates covered by the unnecessary compound that will reduce the bonding between the aggregates when mixing concrete process and the particles of the aggregates are too weak and not solid. With all of this factor, the aggregates will effect the concrete with the chemical reaction between the aggregates and the cement mixing (Neville & Brooks, 1987).

2.2.2 Cement

In general cement can be known as a material might have a concentrated properties which can stick all together to combined it into one object of volume. In terms of construction, cement can be defined as a binder between the aggregates and bricks.

The strength of the hard cement are depends on their mechanics properties, strength of concrete and mortar are also depends on their cement concentration of mixing, adhesive of the aggregates and most factor is strength of the aggregates.

Usually construction will use the Portland cement that content the limestone, alumina and silica. There are many types of Portland cement depend on their purpose and condition. Portland cement will be mixed with the special cement to produce the different types of cement. Most of the cement have been improved to make sure concrete durability at any condition. Somehow, there are never know the specifically cement contains that will exceed the durability concrete problems. The types of Portland cement are listed below:

1. Ordinary Portland Cement
2. Sulphat Resistance Portland Cement
3. White Portland Cement
4. Blastfurnace Portland Cement
5. Pozzolanic Portland Cement
6. Composite Portland Cement
7. High-early-strength Portland Cement
8. Moderate heat of hydration Portland Cement
9. Low heat of hydration Portland Cement

There are many factor will effect the cement properties need to be considered. Besides that, there also have a factors which are permeability of the concrete, shrink of the concrete, resistance due weather and creep.

Table 2.2: Strength of Cement Needed BS 12 : 1978 (Neville, 2008)

Age (days)	Min Compressive Strength							
	Mortar Test				Concrete Test			
	Ordinary Portland cement		High-early-strength Portland Cement		Ordinary Portland cement		High-early-strength Portland Cement	
	MPa	psi	MPa	psi	MPa	psi	MPa	psi
3	23	3300	29	4200	13	1900	18	2600
28	41	5900	46	6700	29	4200	33	4800

2.2.3 Water

In a production of concrete, water plays an important role. It is used in many purpose such as wash aggregates, as a mixing water, during the curing process and to wash out mixers. When the aggregate are coated by the silt, salts, or organic materials, the aggregates must be cleaned and wash out by the water. This to avoid the aggregate and the water may produce distress concrete due to chemical reaction with the cement paste or poor aggregates bonding.

The water also important because it will affect volume stability and cause the leaching of free lime, discoloration and excessive reinforcement corrosion. The salts of manganese, tin, zinc, cooper, and lead may cause reduction in strength and variations in setting times. The use of water containing acids or organic substances should be questioned because of the possibility of surface reactions and retardation (Theodore, 2005).

2.3 Lightweight Concrete

Foamed concrete can be defined as a insulator concrete and concrete with the lower or higher density than the normal concrete which is 2200 to 2600 kg/ m^3. High density of concrete usually used to the biological structure construction and lightweight concrete usually used influenced by the economical factor.

In a construction that used the concrete, imposed load was the larger. Dead load was the larger load that affect the total of the structure so that the factor must be considered to decrease the density of the concrete. The most important part is to use the smaller component to have a smaller suitable base. With the lightweight concrete also, the density of the concrete needed are more less other than the normal concrete which bring the concrete work more easily to produce. For structure, loading are the important part to be considered because of the design and cost are depends on the loading specification. Lightweight concrete are lighter than the normal concrete and it will be a good insulator. Normally, lightweight concrete density are between the 300 to 1850 kg/ m^3 (Neville & Brooks, 1987).

According to Neville and Brooks (2008) also, there are some other properties of lightweight aggregate concretes as compared with normal weight concrete may be of interest such as:

a. For the same strength, the modulus of elasticity is lower by 25 to 50 per cent; hence, deflection are greater.
b. Resistance to freezing than thawing is greater because of the greater porosity of the lightweight aggregate, provided the aggregate is not saturated before mixing.
c. Fire resistance is greater because lightweight aggregates have a lesser tendency to spall, the concrete also suffers a lower loss of strength with a rise in temperature.
d. Lightweight concrete is easier to cut or to have fitments attached.

e. For the same compressive strength, the shear strength is lower by 15 to 25 per cent and the bond strength is lower by 20 to 50 per cent. These differences have to be taken into account in the design of reinforced concrete beams.
f. The tensile strain capacity is about 50 per cent greater than in normal weight concrete. Hence, the ability to withstand restraint to movement such as due to internal temperature gradients, is greater for lightweight concrete.
g. For the same strength, creep of lightweight aggregate concrete is about the same as that of normal weight concrete.

2.3.1 Classification of Lightweight Concrete

There are three general methods to produce lightweight concrete. In the first method, the production by using the porous lightweight aggregate of low apparent specific gravity. This method of change the normal aggregates which have the high density. This methods known as lightweight aggregate concrete. Second method to produce the lightweight concrete are by introducing large voids within the concrete or mortar mass, these voids should be clearly distinguished from extremely fine voids produced by air entrainment. This type of concrete is variously known as aerated, cellular or gas concrete. Lastly the third method by the omitting the fine aggregate from the mix so that a large number of interstitial void is present. Usually, normal weight coarse aggregate is generally used. This concrete is known as no-fines concrete (Neville and Brooks, 2008).

It important to know that the voids ratio, density of the aggregate or mortar could be reduce or not or between the course particle aggregate. It can be proved that the void in the concrete can reduce the strength of the lightweight concrete compared to the normal concrete. In certain case, high strength cant be a measurement to the importance in terms of frequently used. Lightweight concrete have a good thermal insulation and has a satisfactory durability but is not highly resistance to abrasion.

In general also, the lightweight concrete is more expensive than the normal concrete, mixing, handling and placing require more care and attention than the normal concrete. However, many purposes the advantages of lightweight concrete is more than the disadvantages. It can apply to the world wide trend towards more lightweight concrete such as prestressed concrete, high rise buildings and even all roofs.

In concrete construction, self weight usually represent a very large proportion of the total load on the structure. And there are clearly consider the advantages in reducing the density of concrete. Furthermore, with the lightweight concrete, the formwork need withstand a lower pressure than would be the case with normal concrete. It also influenced the total mass of materials to be handled is reduced with consequent increase in productivity. Thus, the case for the use of structural lightweight concrete rests primarily on economic considerations (Neville and Brooks, 2008).

The differences between the types of lightweight concrete are very much related to its aggregate grading used in the mixes. Table 2.3 shows the types and grading of aggregate suitable for the different types of lightweight concrete. Besides that Table 2.4 show that the advantages and disadvantages of lightweight concrete (Samidi, 1997).

Table 2.3: Types and Grading of Lightweight Concrete (Samidi, 1997).

Type Of Lightweight Concrete	**Type Of Aggregate**	**Grading of Aggregate (Range of Particle Size**
No-fines concrete	Natural Aggregate Blast-furnace slag Clinker	Nominal single-sized material between 20mm and 10mm BS sieve
Partially compacted lightweight aggregate concrete	Clinker Foamed slag Expanded clay, shale, slate, vermiculite and perlite Sintered pulverized-fuel ash and pumice	May be of smaller nominal single sizes of combined coarse and fine (5mm and fines) material to produce a continues but harsh grading to make a porous concrete
Structural lightweight aggregate concrete	Foamed slag Expanded clay, shale or slate and sintered pulverized fuel ash	Continues grading from either 20mm or 14mm down to dust, with an increased fines content (5mm and fines) to produce a workable and dense concrete
Aerated concrete	Natural fine aggregate Fine lightweight aggregate Raw pulverized-fuel ash Ground slag and burnt shales	The aggregate are generally ground down to finer powder, passing a 75 μm BS sieves, but sometimes fine aggregate (5mm and fines) is also incorporated