MECHANICAL PROPERTIES OF LIGHWEIGHT CONCRETE ARCH PAN

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ABSTRACT

Nowadays, permanent formwork using arch pan have emerged and been applied widely rather than using conventional method, temporary formwork which is more expensive and produce a lot of wastage in term of time and workers. Recently, permanent formwork is using normal concrete which lead many problem such as the uses of scaffolding. Normal weight concrete is widely used in constructions which provide a balance of strength, workability, durability and economy for general use. However the self-weight beam is too heavy. One of the alternatives to overcome the problems is using lightweight concrete. The objective of the study is to determine the mix design that will produce concrete arch pan that can carry a minimum load of 1 kN, using foam lightweight concrete. This project study also is carried out to determine the strength of lightweight concrete arch pan. Compressive tests and flexural test were carried out for the project report. The strength of lightweight concrete was measured through the test. This research includes the design and fabrication of the arch pan by using the foam lightweight concrete. Based on the result obtained from the testing, it shows that the strength of lightweight concrete arch pan is increasing steadily with time.

ABSTRAK

Pada masa kini, acuan tetap menggunakan pan gerbang telah muncul dan telah digunakan secara meluas daripada menggunakan kaedah konvensional, acuan sementara yang lebih mahal dan menghasilkan banyak pembaziran dari segi masa dan pekerja. Baru-baru ini, adalah acuan kekal menggunakan konkrit biasa yang menyebabkan masalah banyak seperti penggunaan perancah. Konkrit berat badan normal digunakan secara meluas dalam pembinaan yang memberikan keseimbangan kekuatan, kebolehkerjaan, ketahanan dan ekonomi untuk kegunaan umum. Walau bagaimanapun rasuk berat diri terlalu berat. Salah satu alternatif untuk mengatasi masalah menggunakan konkrit ringan. Objektif kajian ini adalah untuk menentukan reka bentuk campuran yang akan menghasilkan pan gerbang konkrit yang boleh membawa muatan minimum 1 kN, menggunakan busa konkrit ringan. Kajian projek ini juga dijalankan untuk menentukan kekuatan ringan pan gerbang konkrit. Ujian mampatan dan ujian lenturan dijalankan bagi laporan projek. Kekuatan konkrit ringan telah diukur melalui ujian. Kajian ini termasuk dalam reka bentuk dan reka pan gerbang dengan menggunakan konkrit busa ringan. Berdasarkan keputusan yang diperolehi daripada ujian itu, ia menunjukkan bahawa kekuatan ringan pan gerbang konkrit semakin meningkat dengan mantap dengan masa.

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INTRODUCTION

1.1 BACKGROUND OF STUDY

In the construction industry, there are always new technologies developed especially in building construction. Nowadays, permanent formwork using arch pan have emerged and been applied widely rather than using conventional method, temporary formwork which is more expensive and produce a lot of wastage in term of time and workers. Referring to Kamran M. Nemati (2007), permanent formwork is a structural element that contains the placed concrete, mould it to the required dimensions and it will remain in place for the lifetime of the structure. Recently, permanent formwork is using normal concrete which lead many problem such as the uses of scaffolding.

By referring to J.L Clarke (1993), the definition for lightweight concrete is one having an air-dry density of less than 1810 kg/m3. It is this true that the application of lightweight concrete is limited to certain purposes compared to normal concrete, but the introduction of lightweight concrete gives more alternative to construction industry, which currently focuses on natural resources. In this research, the main focus is to establish the uses of lightweight concrete which is foamed concrete in the arch pan.

1.2 PROBLEM STATEMENT

In normal construction for the flooring system, the amount of scaffolding use is higher. By apply the arch pan system in the flooring system, it help to eliminate the use of the scaffolding. Normal weight concrete is widely used in constructions which provide a balance of strength, workability, durability and economy for general use. However the self-weight beam is too heavy. One of the alternatives to overcome the problems is using lightweight concrete. Lightweight concrete used to reduce the dead load, to faster construction time, lower haulage and handling cost. However, lightweight concrete is lower in strength although it is lighter.

In Malaysia the use of lightweight concrete is not very common; this may be due to large amount of gravel aggregate still available in the market. Based on the statement, we know that the construction industry in Malaysia have a problem which may be it is not popular relating expensive cost, less knowledge and experience, not having enough the skill worker, the machinery and appliance to constructed the lightweight concrete not enough.

It is this true that the application of lightweight concrete is limited to certain purposes compared to normal concrete, but the introduction of lightweight concrete gives more alternative to construction industry. Some of the lightweight aggregate are manufactured from waste material such as Lytag, whereby it was produced from pulverized fuel ash (PFA) and natural materials, like volcanic pumice. Thus this research wills emphasize on mix design of lightweight concrete.

1.3 RESEARCH OBJECTIVES

The main objectives of this research are as follow:

1.3.1 To identify the compressive and flexural strength properties of lightweight concrete

1.3.2 To design and fabricate the arch pan using lightweight concrete

1.3.3 To determine the flexural strength on arch pan exceeding 1kN force

1.4 RESEARCH QUESTIONS

1.4.1 How to increase compressive and flexural strength of lightweight concrete?

1.4.2 What is the mix design of the lightweight concrete?

1.4.3 What is the maximum load that can be applied?

1.5 SCOPE OF STUDY

This research is conduct:

1.5.1 To explore the mix design of lightweight concrete

1.5.2 To prepare the sample of lightweight concrete to use in the arch pan

1.5.3 To put the sample on the compression machine and the force is applied to collect the data

1.5.4 To determine the flexural strength by using flexural machine test

1.5.5 To put the sample on the flexural machine test and the load is applied on the sample to collect the data

1.6 SIGNIFICANCE OF RESEARCH

In this research, the main purpose is to produce standard design on arch pan system using lightweight concrete. Economically by using lightweight concrete, it will reduce the cost to produce the concrete. Besides by using lightweight concrete help in the reduction of dead load and faster construction time.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Light weight foamed concrete has become more popular in recent years owing to the tremendous advantages it offers over the conventional concrete. Modern technology and a better understanding of the concrete have also helped much in the promotion and use of light weight foamed concrete on concrete arch pan.

This chapter describes the nature of foamed concrete, its composition and properties and how it use in concrete arch pan. Because the properties of foamed concrete can vary widely, and it can be used in a wide variety of applications, it is important to define performance requirements for each case.

2.2 OVERVIEW OF FOAMED CONCRETE

2.2.1 DEFINITION OF FOAMED CONCRETE

Foamed concrete has been defined in several ways; indeed it has number of synonyms such as cellular concrete and there is confusion between foamed concrete and similar materials such as air entrained concrete. A definition, cited by Jones (2005), is that foamed concrete is a cementation material having a minimum of 20 per cent (by volume) of mechanically entrained foam in the plastic mortar. This differentiates foamed concrete from:

(a) Gas or aerated concrete, where the bubbles are chemically formed through the reaction of aluminium powder with calcium hydroxide and other alkalis released by cement hydration.

(b) Air entrained concrete, which has a much lower volume of entrained air.

Other definition, according to Aldridge (2005), that the term foamed concrete is itself misleading with vast majority of concretes containing no large aggregates, only fine sand and with the extremely light weight foamed concrete materials containing only cement, water and foamed, so the product should be more accurately described as having an air content of more than 25%which distinguishes it from highly air entrained. In it is basic form foamed concrete is blend of sand ,cement ,water and pre-formed foam, which in itself is a mixture of foaming agent (either synthetic or protein base), water and air.

2.2.2 HISTORY AND BACKGROUND OF FOAMED CONCRETE

Foamed concrete is not a particularly new material, it is first recorded use date back to the early 1920s. The application of foamed concrete for construction works was not recognized until the late 1970s, when it began to be used in Sweden in 1929s.

The first large foamed concrete project in the UK was completed in 1980 at the Falkirk Railway Tunnel in Scotland. Around 4500m3 of 1100 kg/m3 foamed concrete was placed in the annulus space surrounding the tunnel. The largest project in the UK required around 70,000m3 of 500kg/m3 foamed concrete encapsulating the utilities supply pipe and cable in the road foundation at Canary Wharf in London.

Significant improvements in production methods and quality of foaming agent over the last 16 years have led to increased production of wide range of application such as blocks, void fill and road. From there on, the use of Foamed concrete has been widely spread across world-wide (Andrew & William, 1978).

2.2.3 COMPARISON BETWEEN FOAM CONCRETE AND CONVENTIONAL CONCRETE

Lightweight foamed concrete made with combination of cement, water, fine aggregate and foam agent have very fine pore structure, unlike that made with conventional concrete.

Foam or bubbling agent is used to absorb humidity for as long as the product is exposed to the atmosphere, allowing the hydration process of the cement to continue for its ever-continuing strength development.

As in a normal concrete the greater the air content the weaker the material, so with foamed concrete densities ranging from 300 to 1700 kg/m3 it is not surprising that the lower densities produce the lower strengths and at present even the densities at the upper limits do not produce strengths much above 15 N/mm2 (Aldridge,2005).

2.2.4 MANUFACTURE OF FOAMED CONCRETE

Foamed concrete is produced by entrapping numerous small bubbles of air in cement paste or mortar. Mechanical foaming can take place in two principal ways:

- By pre-foaming a suitable foaming agent with water and then combining the foam with paste or mortar.
- By adding a quantity of foaming agent to the slurry and whisking the mixture into a stable mass with the required density.

To get a high performance and quality foamed concrete, the selection of the materials are very important. The various materials, equipment and procedure are discussed separately below.

2.2.5 BASIC MATERIAL

1. PORTLAND CEMENT

There are many types of Portland cement .high alumina cement; super sulphate and special cement as masonry. Under ASTM standard the type (I, II, III) is preferred to use because its fineness and chemical composition.

However, Ordinary Portland cement (to BS 12:1996 or BS EN 197: Part 1: 2000) is usually used as tile main binder for foamed concrete. However rapid-hardening Portland cement to BS 915:1983 has also been used, and there does not seem to be any evidence why sulphate resisting cement could not be used.

Portland cement is essentially calcium silicate cement, which is produced by firing to partial fusion, at high temperature approximately 1500 C°. It has different rheological and strength characteristics, especially use in combination with chemical admixtures and supplementary cementing materials. Therefore, it is necessary to look at its fitness and chemistry content when choosing.

2. FINE AGGREGATE

Generally the fine aggregate shall consist of natural sand, manufactured sand or combination of them. The fine aggregate for concrete that subjected wetting, extended exposure to humid atmosphere, or contact with moist ground shall not contain any material that deleteriously reactive in cement to cause excessive expansion of mortar concrete.

Recommend that only fine sands suitable for concrete (to BS 882:1992) or mortar (to BS 1200: 1976) having particle sizes up to about 4 mm and with an even distribution of sizes should be used for foamed concrete. This is mainly because coarser aggregate might settle in a lightweight mix and lead to collapse of the foam during mixing.

3. WATER

The water used for foamed concrete should be potable. This is crucial when using a protein based foaming agent because organic contamination can have an adverse effect on the quality of the foam, and hence the concrete produced.

The water/cement (w/c) ratio of the base mix required to achieve adequate workability is dependent upon the type of binder(s), the required strength of the concrete, and whether or not a water reducing or a plasticizing agent has been used. In most cases the value will be between 0.4 and 0.8. The higher values are required with finer grained binders, such as PFA, and the lower values where either a high strength is required or a super plasticizer has been employed.

Where the water content of the mix would be inadequate to ensure full hydration of the cement, water will be extracted from the foam and might lead to its disintegration. On the other hand whilst high w/c ratios do not significantly affect the porosity of the foamed concrete they do promote segregation and increase drying shrinkage (Gambhir, 2004).

4. FOAMED AGENT

Synthetic or protein-based foaming agents (surfactants) can be used to produce foam. Because of the possibility of degradation by bacteria and other organisms, natural protein based agents (i.e. fatty acid soaps) are rarely used to produce foamed concrete for civil engineering works. However research is underway on the use of protein-based agents for developing high strength, i.e... The chemical composition of surfactants must be stable in the alkaline environment of concrete. Because all surfactants are susceptible to deterioration at low temperatures they should be stored accordingly. The properties of foamed concrete are critically dependent upon the quality of the foam. There are two types of foaming agent:

I. Synthetic-suitable for densities of 1000 kg/m3 and above.

II. Protein-suitable for densities from 400 to 1600 kg/m3.

Protein-based foaming agents come from animal proteins out of horn, blood, bones of cows, pigs and other remainders of animal carcasses. Its surfactants might therefore be best suited to the production of foamed concrete of relatively high density and high strength. Optimum performance of foam is commonly attained at a ratio of 1:25, but the optimum value is a function of the type of surfactant and the method of production (Gambhir, 2004).

2.2.6 EQUIPMENT

The production of foamed concrete is a fairly easy process which does not involve any expensive or heavy machinery and in most cases uses equipment that is already available for normal concrete/mortar production. That include:

1. Normal concrete/mortar mixer or special mixers for foam concrete.
2. Foam Generator
3. Formwork (if producing pre- cast components)

2.2.7 MIXING PROCEDURES

At first start with the sand and cement. Mix dry constituents for a few minutes and add water in stages and make sure the mixing is thorough (Mortar slurry preparation). Then, Preparation of pre-foamed by diluted the foam agent with water and extracted by using foam generator and air compressor. After that, add foam to the wet slurry and ensure foam has been completely mixed with the mortar. After mixing is completed check that the wet density of the foamed concrete is close to what is required.

There is no chemical reaction involved when the pre-foamed add into the cement mortar. Introduction of pores is achieved through mechanical means either by pre-formed foamed foaming (foaming agent mixed with part of mixing water) or mix foaming (foaming agent mixed with the mortar) (Yew,2007).

2.2.8 CURING OF FOAMED CONCRETE

Curing is a process of preventing fleshly placed concrete from drying the first during the first day of its life to minimize any tendency to cracking and allow it to develop concrete strength. There are different methods of curing that affect the concrete properties as: water curing, sheet curing, membrane curing and air curing.

2.2.9 BENEFIT OF FOAMED CONCRETE

Foamed contribute to the reduction of building dead weight thus resulting in more economic structural design. Production of more economic structural design will reduce the amount of material used and eventually cutting down the cost of construction project itself resulting in profit increase to the contractor.

Besides that, other researchers added that the lightness of structure makes it easier to be transported and handled. In addition, it's also has a very low thermal conductivity that makes it an excellent fire protection property (John& Ban Choo, 2003).

2.3 PERMANENT FORMWORK

A permanent formwork is a formwork that stays in place for the life of the element it is supporting and becomes a part of the permanent structure of the building. It does not only act as a temporary support to control the shape of the fluid concrete, but it also help to strength the finished concrete structure. They are various types of materials that are being used in generating the permanent formwork including timber, steel decking sheet, concrete, glass reinforced concrete, plastic, fibre-cement form board and polystyrene. The applicability of each material will depend on the requirement durability, strength and appearance of each case.

For a permanent formwork, it must be strong enough to carry the pressure that the fluid concrete can exert. Then, the strength of permanent formwork must endure until the concrete is self-supporting. These characteristic must have in a permanent formwork to enable the structure is durable and have a long life.

2.4 EXAMPLES OF PERMANENT FORMWORK

A) RIB AND BLOCK SUSPENDED SLAB

In this system, non-structural hollow concrete rebated filler blocks are placed between these ribs, which strengthen the floor and become the formwork. The block sizes determine the spacing for the beam and provide a flush soffit. A structural concrete topping of desire strength and thickness is applied over the ribs and blocks to form a slab. Welded mesh is placed in this topping to control possible shrinkage cracks and tensile stress.

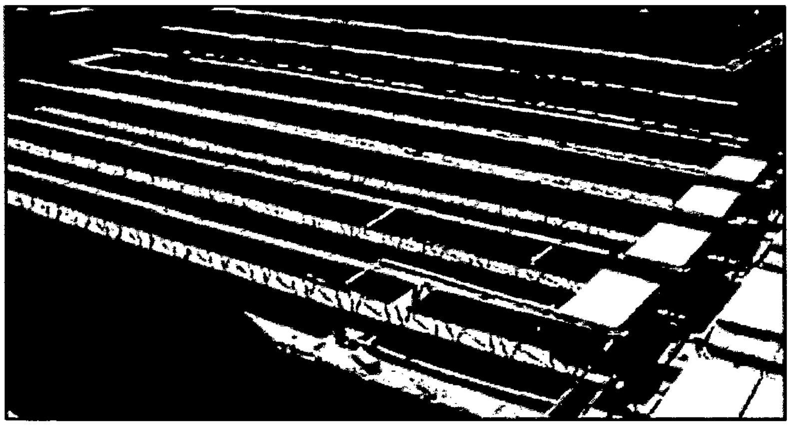

Figure 1 Example of ribs and block suspended slab construction

B) COMPOSITE SLAB CONSTRUCTION

Composite slab use steel decking as both temporary support for the concrete placed on it and as a composite element to withstand the load. The slab span is between support beam, masonry walls or concrete. This steel support the fresh concrete while it sets and hardens. The slab decking looks like corrugated iron roof sheeting where it comes from different profile, which is the shape that the sheeting is mould in.

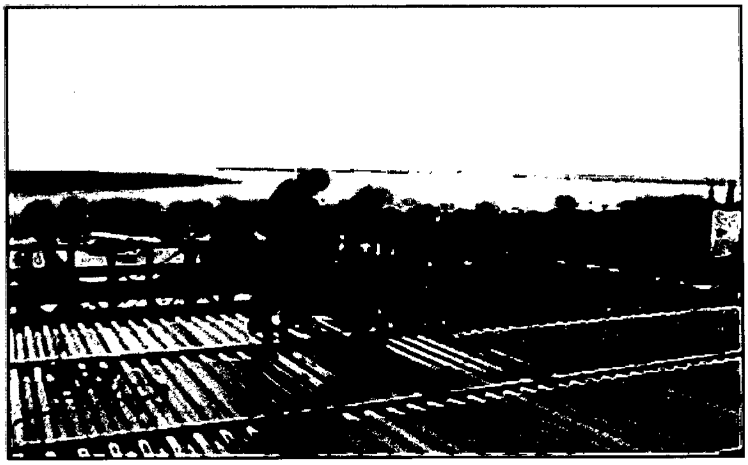

Figure 2 Example of composite slab construction

2.5 THE ADVANTAGES OF PERMANENT FORMWORK

They are several benefits for the application of permanent formwork during construction process including:

a. Site labour saving on site construction
b. Accelerating speed in construction
c. Reduction or elimination of false work
d. Allowing off-site modular fabrication followed by schedule and appropriate deliveries