PERFORMANCE OF TILE AS PERMANENT FOR SLAB

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ABSTRACT

Permanent formwork is chosen to reducing waste in construction as a solution that has benefit compared to the conventional method that using scaffolding for temporary support formwork. Other than that, this research presents the lightweight arch pan to adequate the capability of arch pan serve as permanent formwork for upper floor slab which more lightly than a normal concrete. In conjunction, the scope of this research emphasize more on designing the structure and investigate the adequacy on load application that including beam, arch pan and slab for producing upper floor slab. The slab was tested to failure under three point loading. The result obtained shows the formation continues cracking line appeared indicate that particular slab act as composite structure.

ABSTRAK

Acuan tetap dipilih untuk mengurangkan pembaziran dalam pembinaan sebagai satu penyelesaian yang mempunyai faedah berbanding kaedah konvensional yang menggunakan perancah untuk sokongan acuan sementara. Selain daripada itu, kajian ini membentangkan *arch pan* ringan untuk mengkaji keupayaan *arch pan* berfungsi sebagai acuan tetap untuk papak tingkat atas yang lebih ringan berbanding konkrit biasa. Bersempena itu, skop kajian ini memberi lebih penekanan kepada bentuk struktur dan menyiasat kecakupan aplikasi beban terhadap rasuk, *arch pan* dan papak untuk menghasilkan papak tingkat atas. Papak telah diuji untuk kegagalan di bawah tiga titik beban Keputusan yang diperolehi menunjukkan pembentukan retak talian terus muncul menunjukkan bahawa perbuatan tertentu sebagai papak struktur komposit.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In Malaysia, construction method are still at low levels compared to the other countries that are applied innovative method on their construction work that can reduce working time, reduce labour and material cost, especially waste material at construction site. Other than that, many developers company and the contractor still struggle to follow the current method of development demanding of the government, particularly there are still using a conventional method at construction site. Hence, the new technology existence in construction to overcome these problems is permanent formwork using lightweight concrete which is more useful than conventional methods in terms of the effectiveness of the functions, lighter, safety features and productivity. In line with that, this research presents the design of arch tile as permanent formwork to investigate its adequacy serving for upper floor slab. In addition, an upper floor slab will be made by using an arch pan arranged on top of the beam joist.

The lightweight concrete specimen was made by using protein foaming agent. The density was determined to be 1600 kg/m3. Hence, this research will solve the problem of the usage of excessive scaffolding and formwork. Furthermore, this research will also reduce the amount of manpower needed at site. Recently discovered that, the foam of concrete arch tile as permanent formwork for upper floor slab were utilised at

other countries. This paper mainly focuses on the flexural strength of the performance of foamed concrete arch tile as permanent formwork for upper floor slab.

1.2 Problem Statement

As time and technology advances, Construction industry found a problem in catching up with the pace of current development cause of using more conventional method at construction site. In normal construction for the flooring system, the amount of scaffolding use is higher that slower the construction time when installing it and discard. Introducing the arch pan system in the flooring system as permanent formwork is the way to eliminate the use of the scaffolding at site (Jaillon, L., C. S. Poon, and Y. H. Chiang, 2009). In the research needs to finds the method of producing best arch pan with highest strength and workability.

Besides that, 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 (Ünal, Osman, Tayfun Uygunoğlu, and Ahmet Yildiz, 2007). However, the method of applying lightweight concrete is common problem in Malaysia due to not having skill worker, less knowledge and experience in construction industry. Thus this research will emphasize more about handling lightweight concrete and mix design of lightweight concrete as material using for producing arch pan.

1.3 Objectives of Study

This study was conducted to achieve the following objectives:

i) To determine the density and compressive strength of lightweight concrete to be used as arch pan.

ii) To determine the flexural strength of a slab using arch pan as a permanent formwork.

iii) To investigate experimental determination of maximum load, displacement and mode of failure of slab.

1.4 Scope of Study

This research generally comprehends using permanent formwork in flooring system. All scope of works includes:

- To fabricate the arch pan using lightweight concrete
- To cast the cube for compressive strength testing
- To cast the slab using the arch pan and joists
- To test the strengths of the cubes and arch pan slab
- Test the slab to determine the failure of mode

1.5 Significance of Study

The application of formwork generally uses in construction process. But in Malaysia, using of permanent formwork in construction can be categorized relatively new especially in building house, as most developers and contractor not aware its potential in construction process.

In this research will emphasize more knowledge on lightweight permanent formwork, as benefit in save site labour on-site, reduce the false work and more economical. Nevertheless, this study will contribute further engineering construction a new in structural design in the future.

In the end, hopefully the development in flooring system using a permanent formwork can be convinced people the potential and its attribute compared to the conventional process.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, explained clearly about formwork. The content also will explain about material and method that being used for construct upper floor slab. The permanent formwork will act as composite structure that consist of arch pan and beam joists.

2.1.1 Permanent Formwork

Formwork has been in use since the beginning of concrete construction. It is a die or a mold that supporting all structures, used as a shaped and support concrete until it achieve strength to carry its own weight. Since developments in formwork can faster construction time, reduce labor and material cost and also waste material at construction site. Hence many type of formwork those uses in construction today that have new material in it such as steel, plastics and fiberglass.

In this research, permanent formwork has been used as development in flooring system. A permanent formwork is not temporary where it is stay with the slab as a permanent supporting for the structure and become element structure of the building.

There are types in preparing formwork which is has a pan with different rise of dimensions. An improved concrete slab and steel construction wherein a pan is extended between adjacent joists, said pan having a bend line axially along its length, a portion of said pan resting a joist, a second portion being transversely notched such that said pan straddles adjacent joists at said notches, said pan serving to support poured in place concrete such that said concrete haunches down to supporting beams, thereby forming a composite concrete slab and steel structure (McManus, 1979).Other than that, the arrangement is such that the pan can remain in place and thus provide a finished ceiling effect. The system further provides an ability to run air-conditioning, electrical, plumbing and other conduits through the slab itself after the slab has been poured (Maclean Charles C, 1969).

2.1.2 Lightweight Concrete

Lightweight concrete have been use a lot now at construction site according to current method that demanding from the government proposed new technology in construction process that more efficient based on time management, material cost and also labor cost. That have a lot type of lightweight concrete were made such as Palm Oil Fuel Ash (POFA), Autoclaved aerated concrete (AAC) or foamed concrete and lightweight aggregate concrete.

For this research using foamed concrete as a lightweight concrete type. According to the journal by (Scrivener, 2001), the concrete with saturated lightweight aggregate exhibited no autogenously shrinkage, whereas the normal-weight concrete with the same matrix exhibited large shrinkage. A partial replacement of normal-weight aggregate by 25% by volume of saturated lightweight aggregate was very effective in eliminating the autogenously shrinkage and restrained stresses of the normal-weight concrete. It should be noted that the internal supply of water from the saturated lightweight aggregate to the high-strength cement matrix caused continuous expansion, which may be related to continuous hydration.

2.1.3 The Arch Concept

The development in arch concept as shown more on Roman structure has a grateful structure. For this research using arch concept according AASHTO LRFD as design codes for the arch. According to (Jiho Moon, 2009), AASHTO LRFD provides good predictions of buckling strengths for the parabolic arches under only axial compression, while the bilinear interaction relationship provides conservative values for the in-plane strength of parabolic arches due to the use of constant reduction factors that can be applied regardless of loading and boundary conditions.

For this research, the type of arch chosen is two pinned symmetrical parabolic arch as shown in Figure 1.1.Below is parabolic equation: (Karnovsky, 2012)

Ordinate y of any point of the central line of the parabolic arch is:

$$y = \frac{4fx(L-x)}{L^2}$$

Where;

f = height of arch

x = vertical distance

L = Length of span

y = horizontal distance

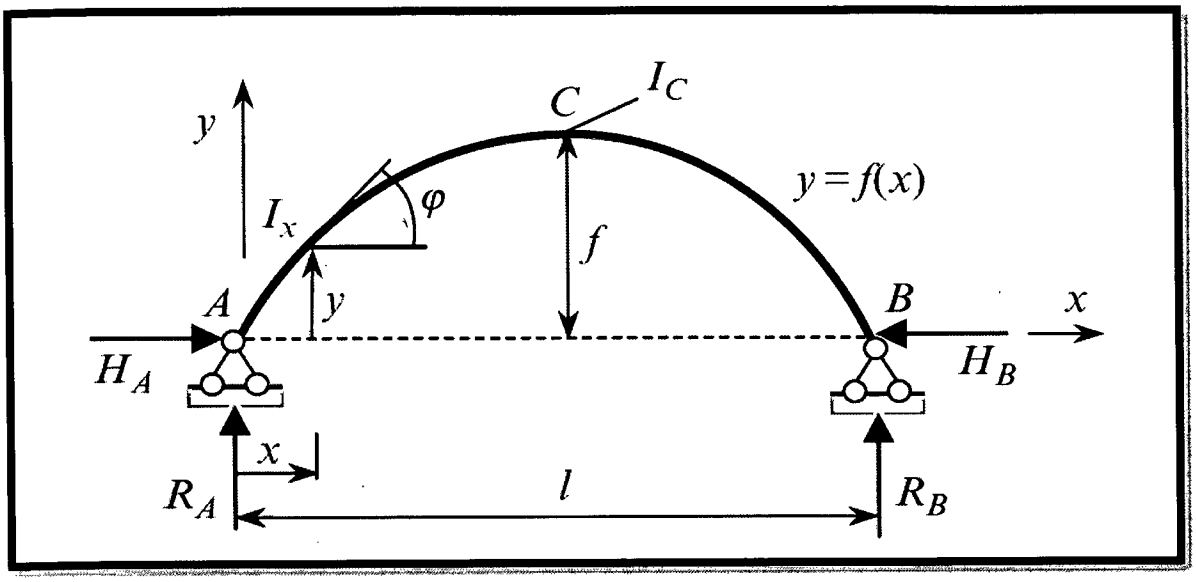

Figure 2-1: Design of two-hinged arch

2.2 Material

2.2.1. Concrete

Ordinary Portland Cement (OPC) most common type of cement that uses around the world, usually for use as an ingredient in basic concreting, mortar and grouting process. According to (BSI 12:1996, 1996), Cement is a hydraulic binder, i.e. it is a finely ground inorganic material which, when mixed with water, forms a paste which sets and hardens by means of hydration reactions and processes and which, after hardening, retains its strength and stability even under water. According to the ASTM standard have five types of Portland cement, designated Types I-V. Physically all different types of cement have their own functionality uses for construction work. Table below will show more specifically about characteristics and applications types of Portland cement (Thomas & Dr. Hamlin Jennings).

Table 2-1: Main types of Portland cement

	Classification	Characteristics	Applications
Type I	General purpose	Fairly high C_3S content for good early strength development	General construction (most buildings, bridges, pavements, precast units, etc)
Type II	Moderate sulfate resistance	Low C_3A content (<8%)	Structures exposed to soil or water containing sulfate ions
Type III	High early strength	Ground more finely, may have slightly more C_3S	Rapid construction, cold weather concreting
Type IV	Low heat of hydration (slow reacting)	Low content of C_3S (<50%) and C_3A	Massive structures such as dams. Now rare.
Type V	High sulfate resistance	Very low C_3A content (<5%)	Structures exposed to high levels of sulfate ions
White	White color	No C_4AF, low MgO	Decorative (otherwise has properties similar to Type I)

**(Thomas & Dr. Hamlin Jennings)*

Type III cement is designed to develop early strength more quickly than a Type I cement. This is useful for maintaining a rapid pace of construction, since it allows cast-in-place concrete to bear loads sooner and it reduces the time that precast concrete elements must remain in their forms. These advantages are particularly important in cold weather, which significantly reduces the rate of hydration (and thus strength gain) of all portland cements. The downsides of rapid-reacting cements are a shorter period of workability, greater heat of hydration, and a slightly lower ultimate strength **(Thomas & Dr. Hamlin Jennings)**.

2.2.2 Fine Aggregates

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and portland cement, are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into two distinct categories-fines and coarse. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch (9.5-mm) sieve. Coarse aggregates are any particles greater than 0.19 inch (4.75 mm), but generally range between 3/8 and 1.5 inches (9.5 mm to 37.5 mm) in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

According to (BS 882:1992, 1992) fine sands 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.

2.2.3 Foamed Concrete

Lightweight concrete have been use a lot now at construction site according to current method that demanding from the government proposed new technology in construction process that more efficient based on time management, material cost and also labor cost. That have a lot type of lightweight concrete were made such as Palm Oil Fuel Ash (POFA), Autoclaved aerated concrete (AAC) or foamed concrete and lightweight aggregate concrete.

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with the same matrix exhibited large shrinkage. A partial replacement of normal-weight aggregate by 25% by volume of saturated lightweight aggregate was very effective in eliminating the autogenously shrinkage and restrained stresses of the normal-weight concrete. It should be noted that the internal supply of water from the saturated lightweight aggregate to the high-strength cement matrix caused continuous expansion, which may be related to continuous hydration.

2.3 Method

2.3.1 Arch Design

The study about arch can be polygonal, parabolic, circular, and other curve in shaped. Arch important in ability the resist the vertical loading and transfer into manageable compressive stress. Arch concept was described earlier study in design permanent formwork. The optimum of height of the concrete arch pan can be obtained is 75mm which the design two-pinned symmetrical parabolic arch. Other than that, the height 75mm of the arc pan and size of pan 550mm can successfully without cracking resist 1000N load (Zarriqbar, 2013).

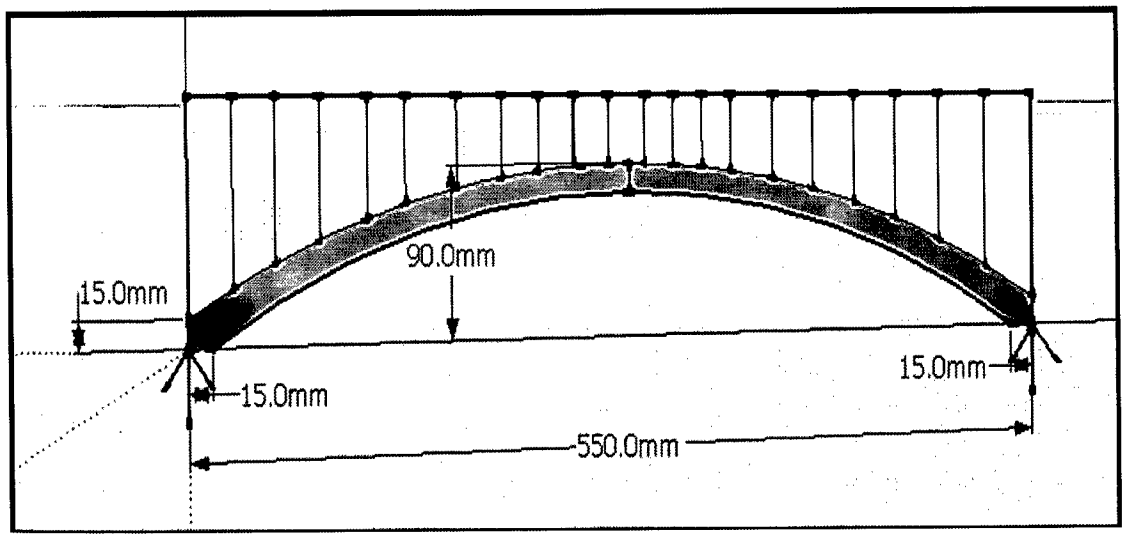

Figure 2-2: The arch design (Zarriqbar,2013)

From this research also, furnished using a plastic mesh netting as reinforcement for increase the flexural strength of the concrete arch pan. From that research, small size-longitudinal netting provides the highest tensile strength.

The arch pan also can serves as arch tiles for upper floor adequately as a permanent formwork recently. In the research by (Brendan, 2010), the higher rises of

dimension much stronger than lower rise of dimension with fixed on measurable span and thickness. By using fixed size of span 530mm and thickness 15mm, the rise of height 75mm was compared to height of 50mm.This is because sample 75mm possess higher load bearing capacity than sample 50mm.

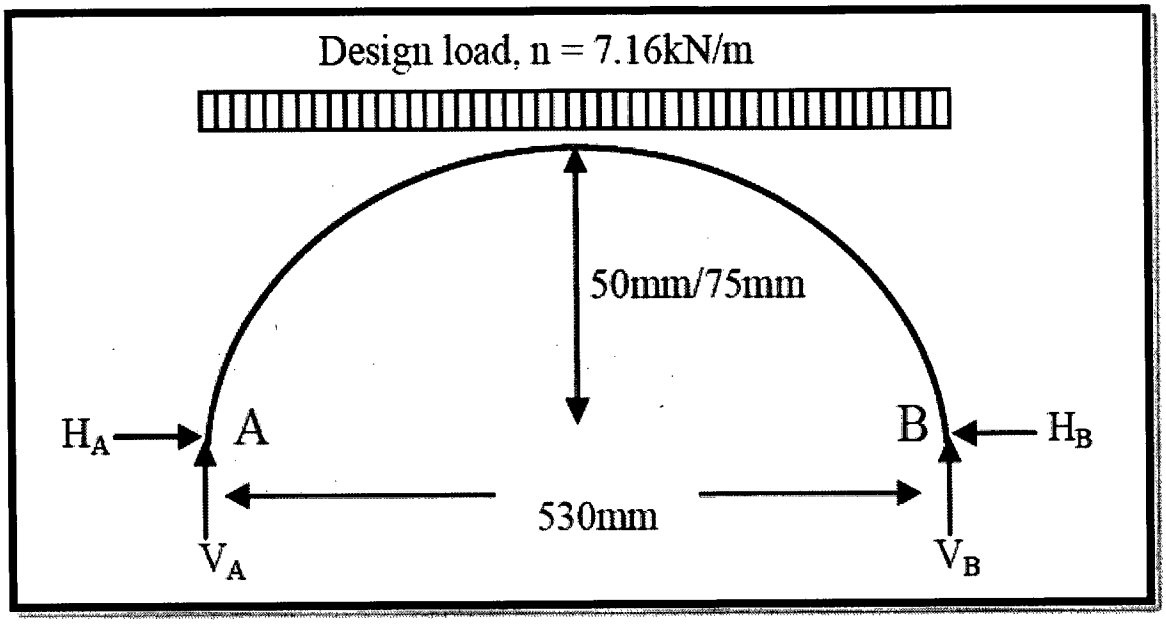

Figure 2-3: The arch design (Brendan, 2010)

2.3.2 Lightweight Concrete Density Design

For this research will determine the suitable density can be used for arch pan that can serves as permanent formwork. Besides that, density can be form for lightweight concrete especially for block construction from 300 to 1200 kg/m^3. For structural concrete the suitable density from 1000 to 2000 kg/m^3 respectively (Osman Ünal, 2007).

Other than that, the main factors that will affect the density of lightweight aggregate concrete are the grading of the aggregates, moisture content, cement percentage, mix proportions and chemical admixtures. Mostly, the density of lightweight aggregate concrete depends on the method of compaction and curing

conditions. The density of structural lightweight aggregate concrete does not exceed 1850 kg/m^3 for normal concrete.

2.3.3 Previous research on development of arch tile

Table 2-2: Previous research

No	Article Title, Author, Journal/Proceedings/ etc.	Summary of Article	Important Data
1	**Effect On Flexural Strength Due To External Side Reinforcement** **NASRUDDIN BIN MD JARIMAN, UMP Thesis Report, June 2013**	-External reinforcement to be replaced on the side of the joist -Using ASTM C78 / C78M for test flexural on concrete -Four point on flexural test -The flexural strength of concrete is given by the expression: $fct = \frac{3f}{d^2}(\frac{N}{mm^2})$ Where F is the maximum load in Newton d is the length of the side of specimen in mm	-Average data on compression test on cube 7 days: 17.75 (N/mm^2) 28 days:29.40(N/mm^2) $-compressive\ strength, \sigma = max.loading(kN) / surface\ area$ -Cracking start at 0.5kN,1.4kN,1.6kN on different joist -Flexural strength 13.9pa,15.8pa,14.3pa

2	**Design Of Arch Tiles As Permanent Formwork For Upper Floor Slab** **Brendan Jawan Anak Richard Tegang.** **UTM Thesis report** **April 2010**	-Comparison height of arch tile between 50mm and 75mm - Using fixed size of span 530mm and thickness 15mm, the rise of height 75mm was compared to height of 50mm.This is because sample 75mm possess higher load bearing capacity than sample 50mm	-Compressive strength of concrete: Beam:28.84 (N/mm^2) Slab : 32.48 (N/mm^2) -Testing slab: load vs displacement Using Universal Testing Machine Take every 20kN increment -75mm more stronger compare to 50mm rise of dimension of arch that poses higher load bearing capacity -Check serviceability limit $l/250$: 150kN and 135kN -
3	**Structure Construction Materials: Casting And Strength Of Concrete Arch Pan** **WAN ZARRIQBAR HAKIM BIN WAN HILMI.** **UMP Thesis Report, June 2013**	- The optimum of height of the concrete arch pan can be obtained is 75mm which the design two-pinned symmetrical parabolic arch -the height 75mm of the arc pan and size of pan 550mm can successfully without cracking resist 1000N load	-Dimensions arch 550x600x15 mm - Average data on compression test 12.61(N/mm^2) -75mm determine optimum of height of arc pan can -resist 1000N on flexural load without cracking -using of plastic mesh as reinforcement increase the tensile strength

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this study several methods will be applied to achieve the experiment will be explained. The methodological procedures are prepared to assure the objectives are applicable, and to secure proper sequence and smooth running of the entire project.

This project involved in testing flexural strength on upper floor slab samples. According to ASTM Designation: E4, we are using Linear Displacement Transducer to record the bending displacement is being prepared. Then, we can determine the flexural strength with testing slab samples using third point loading.

3.2 Experimental Program

This lab investigation will be carried out at the structure lab, Faculty of Civil Engineering, Universiti Malaysia Pahang. This research will be supervised by Prof. Datin Dr. Nasly Binti Mohamed Ali and Madam Shariza Binti Mat Aris. Other than that, the preparation of foam concrete will be supervised specially by Madam Rokiah Binti Othman.