THE EFFECT OF MICROWAVE INCINERATED RICE HUSK ASH ON THE STRENGTH OF FLOATING FOAMED MORTAR

by

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CERTIFICATION OF APPROVAL

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Approved by,

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MD UZAIR FIDAIY BIN ZUKAINAIN

Abstract

This study is focusing on the effect of MIRHA in increasing the strength of floating foamed mortar. Foamed concrete that has density lower than 1000kg/m^3 would be floating in the water but its compressive strength would be too low to be used in construction. So, the objective of this research was to determine the optimum MIRHA percentage to be used to increase the compressive strength of floating foamed mortar until it exceeded the minimum requirement of compressive strength which is 3.45 Mpa. For each percentage of MIRHA (0%, 5% and 20 %), 9 cube specimens with dimension of 100x100x100 mm are made for split tensile test which will be tested for 28th days. The cube specimens are fairly distributed for tests at 3rd days, 7th days and 28th days. For the mix of MIRHA and other pozzolan material like silica fume and GGBS, 18 cubes of 55x55x55 mm are made for compressive strength test wihich will be tested for 28th days. The specimens were subjected to wet curing for hydration process. The experimental results show that mix containing MIRHA presented higher compressive strength and with the exception of second mix that contains 5% of MIRHA, all other six has surpassed the minimum requirement compressive strength. The sixth mix that contains 10% of MIRHA and 20% of slag has achieved highest compressive strength which is 5.6 Mpa that exceeded required strength by 62%

Keyword: MIRHA, floating foamed concrete, compressive strength

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

One of the most useful features of a lightweight concrete system is the system's ability to be manufactured in a wide range of low densities and strengths. Application requirements for lightweight concrete range from very light density low strength fill dirt replacement to higher strength structural lightweight concrete.

At the lower densities, lightweight concrete will float, and in many cases float indefinitely and can be used for marine floatation. Because of its limited impact and abrasion resistance, lightweight concrete used for marine flotation should be encased and used for the fill of a float. For example, a marine float could be made with sealed drums filled with low-density lightweight concrete [1].

"Floating Dwelling" can be built completely from foamed concrete from floating platforms to structural and non-structural building components and assemblies including roofing and landscaping. Densities are engineered depending on the mechanical properties and insulation characteristics required. The cost of producing a dwelling unit using foamed concrete is three times cheaper than using normal concrete [2]. So this research has been done to find a way to increase compressive strength of foamed concrete that has density lower than water density so it can be used in construction like for "Floating Dwelling".

1.2 PROBLEM STATEMENT

The new concept has attracted industries and individual to explore for actual scale. "Floating Dwelling" can be built completely from foamed concrete from floating platforms to structural and non-structural building components and assemblies including roofing and landscaping. The foamed concrete is preferred since its cost is cheaper than ordinary concrete Densities are engineered depending on the mechanical properties and insulation characteristics required. The density control is achieved by adding a calculated amount of foam to slurry of water and cement, with or without the addition of sand or aggregate. However with the lower density, the compressive strength of the concrete is also dropped.

This research is focused on the effect of MIRHA which has material composition that is highly reactive so it can be used as cement replacement material, and also the optimum replacement percentage of MIRHA/OPC that is required to increase the compressive strength of floating foamed mortar. There will be also a mix of MIRHA and other pozzolan material like silica fume and ground granulated blastfurnace slag in the mix design to be able to establish effect on the mortar. The criteria that needed to be fulfilled in this research are the minimum compressive strength is 3.45 MPa which is the requirement for non load bearing like wall structure [3] for while the maximum density must still be lower than water density which is 1000 kg/m^3 for the mortar to float.

1.3 OBJECTIVES

The main objectives of this research are:

1. To determine the optimum of mix proportion for Floating foamed mortar using MIRHA as cement replacement material with minimum compressive strength equal to 3.45 MPa

2. To establish the effect of MIRHA only and mix of MIRHA with other pozzolan material on the strength of floating foamed mortar with water binder ratio = 0.5

1.4 SCOPE OF STUDY

The scope of the study will comprises on the effect of using MIRHA with percentage on 0, 5, and 20 percent as cement replacement material in mortar with density of 900 kg/m3 and below. There will be also a mix of MIRHA and other pozzolan material like silica fume and ground granulated blastfurnace slag where the mix is done with 10% of MIRHA and silica fume together with 20% of slag. Then the mix is done with 10% of MIRHA and 20% of slag. There is also a mix with 10% of MIRHA and silica fume.

Then the analysis of mortars characteristic namely, their compressive strength and tensile strength are done for the hardened mortar, Compressive strength test will be test on MIRHA mortar samples with size 100x100x100 mm. The ages of tests are 3, 7, and 28 days and about 0, 5, and 20 percent of MIRHA and 3 mix of MIRHA with other pozzolan material will be mixed with density mortar of 900 kg/m^3 and below. For split test, MIRHA mortar sample sizes are 200 x diameter 100mm which will be tested for 28 days.

CHAPTER 2
LITERATURE REVIEW

2.1 LIGHTWEIGHT CONCRETE

Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as nailibility and lessened the dead weight. It is lighter than the conventional concrete with a dry density of 300 kg/m3 up to 1840 kg/m3; 87 to 23%lighter [3].

Structural lightweight concrete made with rotary kiln produced structural lightweight aggregate solves weight and durability problems in buildings and exposed structures. Structural lightweight concrete has strengths comparable to normal weight concrete, yet is typically 25% to 35% lighter. The main specialties of lightweight concrete are its low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates in construction, lower haulage ,handling costs, thinner sections, decreased story height, smaller size structural members, less reinforcing steel, and lower foundations costs [3]. Structural lightweight concrete precast elements have reduced trucking and placement costs. The density of concrete can be reduced by replacing some of the solid material in the mix by air voids. On the other hand, lightweight concrete has higher cement content than normal weight concrete.

There are 3 possible locations of the air: in the aggregate particles, which are known as *lightweight aggregate;* in the cement paste the resulting concrete being known as cellular concrete or foamed concrete; and between coarse aggregate particles, the fine aggregate being omitted. Concrete made in the last named manner is known as *no-fines concrete* [4].

Lightweight concrete has been used since the eighteen centuries by the Romans. The application on the 'The Pantheon' where it uses *pumice* aggregate in the construction of cast in-situ concrete is the proof of its usage. In USA and England in the late nineteenth century, *clinker* was used in their construction for example the 'British Museum' and other low cost housing. The lightweight concrete was also used in construction during the First World War. The United States used mainly for shipbuilding and concrete blocks. The *foamed blast furnace-slag* and *pumice aggregate* for block making were introduced in England and Sweden around 1930s. Nowadays with the advancement of technology, lightweight concrete expands its uses. Ones of its examples is in the form of perlite with its outstanding insulating characteristics. It is widely used as loose-fill insulation in masonry construction where it enhances fire ratings, reduces noise transmission, does not rot and termite resistant. It is also used for vessels, roof decks and other applications [1].

2.1.1 Foamed Concrete

One of the method of reducing the density of concrete relies on the introduction of stable voids approximately 0.1 to 1 mm size that been produced by gas or air within the hardened cement paste or mortar. Since this air is introduced by a foaming agent, the term *foamed concrete* is used. It can be produced anywhere in any shape or building unit size using conventional equipment and machines and be cost-effective and simple to produce. The basic contribution of foamed concrete to the field of concrete technology is the ability to control its density over a wide range. The fresh density of foamed concrete typically ranges from approximately 320 to 1920 kg/m^3. The density control is achieved by adding a calculated amount of foam to slurry of water and cement, with or without the addition of sand and aggregate. However, the skin of air voids must be tough during which the air voids are separated, coated with cement paste, and the concrete can be pumped or transported to the casting location [5].

The preformed foam process of making foam concrete is the most economical and controllable pore-forming process, consisting of stable, unconnected air voids. However, under some circumstances, the air voids may also coalesce during mixing and transporting and form larger air voids. Generally, air voids that govern the porosity of foamed concrete are considered to have a significant effect on compressive strength of the concrete [5].

The very lightest mixes (from 300 kg /m3 to 800 kg / m3) are often made using only foam as the sand and aggregate are eliminated, and are referred to as floating lightweight concrete. Foam concrete with this densities is used in roof and floor as insulation against heat and sound and is applied on rigid floors (i.e. in itself it is not a structural material). It is used interspaces filling between brickwork leaves in underground walls, insulation in hollow blocks and any other filling situation where high insulating properties are required.

The entrapped air takes the form of small, macroscopic, spherically shaped bubbles uniformly dispersed in the concrete mix. Today foams are available which have a high degree of compatibility with many of the admixtures currently used in modern concrete mix designs. Foam used with either lightweight aggregates and/or admixtures such as fly ash, silica fume, synthetic fiber reinforcement, and high range water reducers (aka superplasticizers), has produced a new hybrid of concrete called lightweight concrete materials, or LCM. For the most part, implementation of Lightweight Composite design and construction utilizes existing technology. Its uniqueness, however, is the novel combination drawing from several fields at once: architecture, mix design chemistry, structural engineering, and concrete placement [1].

2.1.1.1 Advantage of Foamed Concrete

i. Foamed concrete is very reliable since it is almost ageless and everlasting material not subject to the impact of time. It does not decompose and is as durable as rock. High compression resistance allows using produce with lower volumetric weight while construction, which increases the temperature lag of a wall [4].
ii. Due to high temperature lag, buildings constructed from foam concrete are able to accumulate heat, which allows minimizing heating expenses by 20-30%. This makes it very suitable to be used for house construction. Foam concrete also humidity proof, and allows avoiding very high temperatures in hot afternoon and controlling air humidity which would be common problem in Malaysia.
iii. Foamed concrete also environmental friendly since during maintenance, foam concrete does not produce toxic substances and in its ecological compatibility is second only to wood. Compare: the coefficient of ecological compatibility of porous concrete is 2; of wood 1; of brick 10; of keramzite blocks 20.
iv. Foam concrete produce protect from fire spread and correspond to the first degree of refractoriness, which is proved by tests [6].

2.1.1.2 Disadvantage of foamed concrete

i. Compressive and flexural strength will degrade typically as a function of density
ii. Very sensitive with water content in the mixtures
iii. Difficult to place and finish because of porosity and angularity of the aggregate. In some mixes, the cement mortar may separate the aggregate and float towards the surface
iv. Unless purpose designed equipment is used mixing may be a problem as the foam tends to float at the surface of the mix and thus its effectiveness is diminished. Issue readily addressed is injecting foam into rather than on to mix in the case of an open mixer, or in the case where foam is introduced into a flowing product line it is not a problem [4].

2.1.1.3 Wet foam

Wet foam is produced by spraying a solution of foaming agent (usually synthetic) and water over a fine mesh. This action causes a drop in pressure across the mesh allowing air to be sucked from atmosphere to equal the pressure. This equalization of pressure causes the solution to expand into what can best be described as foam similar in appearance to bubble structure and although relatively stable it is not recommended for the production of low density (bellow 1100 kg/m^3) foamed materials. It is also not suitable for pumping long distances or pouring to any great depth [7].

According to Pan PacificEngineering Pty Ltd, one liter of foam agent should be diluted with 40 liter of clean water and it makes the ratio of 1:40 but according to Alex Liew on his paper of work of Lightweight Concrete Method, LCM the ratio should be 1:30 [4]. However it can be concluded that of the ratio between 1:30 and 1:40 can be applied to the foam agent and water.

2.1.1.4 Dry Foam

Dry foam is produced by forcing a similar solution of foaming agent and water through a series of high density restriction whilst at the same time forcing compressed air in to a mixing chamber. The action of forcing this pressurized air into the solution expands the solution into thick, tight foam, similar in appearance to shaving foam. The bubble size is typically less than 1 mm in diameter and of an even size. This type of foam is extremely stable and these stable properties are passed onto foamed materials when the foam is blended with the base materials.

As detailed previously this stability is particularly important when the ratio of foam to base materials is greater than 50:50. When the foam becomes the dominant partner within the mix it has to retain its stability to avoid collapse during, pumping, curing, pouring, etc. A foamed concrete produced using dry foam can be pumped further, poured deeper and exhibits better flow characteristics than a like for like mix produced with a wet foam system.

2.2 CEMENT REPLACENT MATERIAL

A number of industrial waste products can be added to ordinary Portland cement to form blended cements. As well as cement replacement materials, these materials are often called material admixtures or the more descriptive supplementary cementing materials. They all contain significant amounts of silica in a finely divided active form, which is capable of dissolving in the high PH pore solution of hydrating OPC to form further calcium silica hydrate. Provided the waste products are less expensive than OPC, and are readily available in a suitable form, it is common practice to use them as cement replacement materials. In many case, these mineral admixtures react more slowly than OPC, giving increased strength and improved impermeability to the hardened cement paste at later ages [8].

2.1.2 Microstructure Incinerated Rice Husk Ash (MIRHA)

Rice is cultivated as a major agricultural food crop in 75 countries of the world. About 400 million tons of paddy rice is produced annually in these countries. Based on various studies and research work, it is established that 1 ton of rice husk is generated from every 5 tons of paddy; thus, there should be about 80 million tons of rice husk available annually worldwide of which 64 million tons are produced in the Far East countries [9].

The chemical composition of rice husk is similar to that of many common organic fibers and contains: a) cellulose (C,H,,O,), a polymer of glucose, bonded with B-1.4, b) lignin (C,H,,O,), a polymer of phenol, c) hemicellulose, a polymer of xylose bonded with B-1.4 whose composition is like xylem (C,H,O,), and d) SO,, the primary component of ash . The holocellulose (cellulose combined with hemicellulose) content in rice husk is about 54%, but the composition of ash and lignin differ slightly depending on the species. The critical composition of rice husks from different species also varies slightly. After burning, most evaporable components are slowly lost and the silicates are left. The characteristics of the ash are dependent on the components, temperature and time of burning. In order to obtain an ash with high pozzolanic activity, the silica should be held in a non-crystalline state and in a highly microporous structure .Hence; the burning process should be controlled to remove the cellulose and lignin portion while preserving the original cellular structure of rice husk.

Traditional open-field burning can create air pollution that is suspected to cause lung and eye diseases within the human population, as well as damage to plant life.

The increasing demand for rice by the growing populations in the rice-eating regions of the world creates an upward trend in the annual production of paddy rice. Due to the improvement in the milling process, there is also an expected increase in the amount of rice husk to be generated. The disposal of this low value by-product-rice husk-will continue to pose as a problem to the 75 countries where rice is grown. Apart from the construction potentials of rice husk its conversion into ash cement is, therefore, a better alternative to the present-day dumping and burning methods of disposing it [10].

Apart from its potential use as low grade fuel, insulation material and filler, microstructure incinerated rice husks ash can be used as a pozzolana to replace, partially, cement and also to be used in block-making.

Current researches have shown that partial replacement of OPC with MIRHA will improve the concrete performance, either its strength or durability [8]. Since the pozzolanic reactivity of MIRHA is influenced by the presence of high silica content and large internal surface area, the burning process should be controlled to remove the cellulose and lignin portion while preserving the original cellular structure of rice husk. The silica also should be held in a non crystalline state and in highly micro porous structure [9].

2.2.1.1 Procedure for Microwave Incineration

It is important to use a proper burning method to be able to get RHA with high reactive silica content. Modern incinerator is designed to avoid environmental problem as caused by open burning. Microwave incinerator as one of the modern incinerators is proposed to produce amorphous RHA with high pozzolanic reactivity as a result this can significantly enhance the concrete properties.

Microwaves are part of the electromagnetic spectrum and are located between 300 MHz and 300 GHz. Microwave heating is defined as the heating of a substance by electromagnetic energy operating in that frequency range. There is a fundamental difference in the nature of microwave heating when compared to conventional methods of heating material. Conventional heating relies on one or more of the heat transfer mechanisms of convection, conduction, or radiation to transfer thermal energy into the material. In all three cases, the energy is deposited at the surface of the material and the resulting temperature gradient established in the material causes the transfer of heat into the core of the object. Thus, the temperature gradient is always into the material with the highest temperatures being at the surface [11].

In microwave heating, the microwave energy not only interacts with the surface material but also penetrates the surface and interacts with the core of the material as well. Energy is transferred from the electromagnetic field into thermal energy throughout the entire volume of the material that is penetrated by the radiation. Microwave heating does not rely on conduction from the surface to bring heat into the core region. Since the heating rate is not limited by conduction through the surface layer, the material can be heated quicker. Another important aspect of microwave heating is that it results in a temperature gradient in the reverse direction compared to conventional heating. That is to say, the highest temperature occurs at the centre of the object and heat is conducted to the outer layer of the material [11].

2.2.1.2 Compressive Strength and Permeability

The addition of pozzolanic materials can affect both strength and permeability by strengthening the aggregate-cement paste through pozzolanic reaction [13, 14]. This phenomenon is shown in Figure 2.3. It is known that the pozzolanic reaction modifies the pore structure. Products formed due to the pozzolanic reactions occupy the empty space in the pore structures which thus becomes densified. The porosity of cement paste is reduced, and subsequently the pores are refined. Mehta (1992) has shown significant reduction in the porosity of cement paste with MIRHA additions and refinement in the pore structure. Pozzolanic reaction is a slow process and proceeds with time [6].

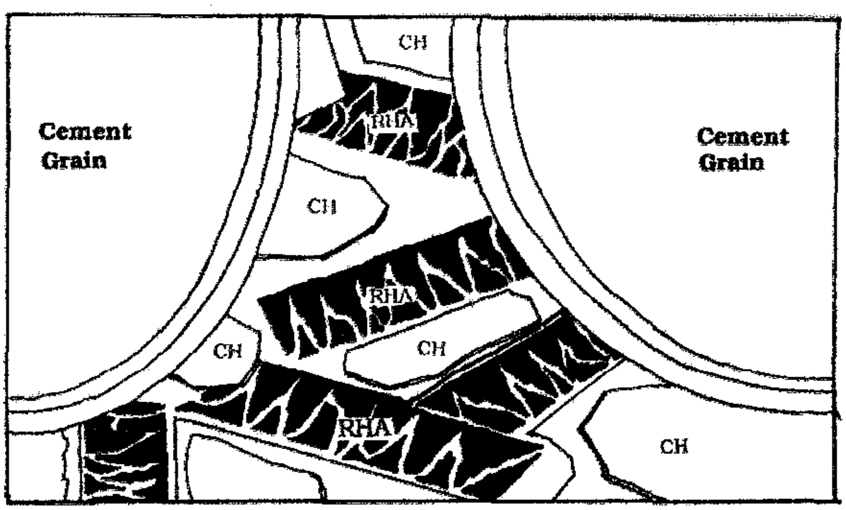


Figure 1: Mechanism of void filling and transition zone strengthening effect of MIRHA [6]

2.2.2 Silica Fume

Neville A.M. (2005, p.86) stated that "silica fume is a by product of the manufacture of silicon and ferrosilicon alloys from high purity quartz and coal in a submerged-arc electric furnace. The escaping gaseous SiO oxidizes and condenses in the form of extremely fine spherical particles of amorphous silica (SiO_2); hence, the name silica fumes. Silica in the form of glass (amorphous) is highly reactive and the smallness of the particles speeds up the reaction with calcium hydroxide produce by the hydration of Portland cement. The very small particles of silica fume can enter the space between the particles of cement and thus improve packing". Addition of silica fume also reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion, especially in chloride-rich environments such as coastal regions and those of northern roadways and runways (because of the use of deicing salts) and saltwater bridges.

The specific gravity of silica fume is generally 2.20 but it is slightly higher when the silica content is lower. Silica fume has a very fine particle which diameter ranged between 0.03 and 0.3 μm. Using nitrogen adsorption method, it is indicated that the specific surface of silica fume is about 20 000m^2/kg [4].

Such as a fine material as silica fume has a very low bulk density which around 200 to 300 kg/m^3. This has caused the handling process of silica fume became difficult and expensive. Because of this, silica fume is available in the densified form of micropellets (Figure2), that is agglomerates of the individual particles (produced by aeration), with a bulk density of 500 to 700 kg/m^3. Another form of silica fume is slurry of equal parts by mass of water and silica fume. The density of slurry is about 1300 to 1400 kg/m^3. The slurry is stabilized and has been reported to have a pH of about 5.5 but this is of no consequences with respect to the use of concrete. Periodic agitation is necessary to maintain a uniform distribution of the silica fume in the slurry. Admixtures such as water reducers, superplasticizers or retarders can be included in the slurry.

Each of the different forms in which silica fume is available has operational advantages but all forms can be successfully used; claims of significant beneficial effects of one or other of these forms upon the resulting concrete have not been substantiated [4].

Figure 2: Silica Fume

2.2.3 *Ground Granulated Blastfurnace Slag (GGBS)*

Ground granulated blast furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. When GGBS is blended with Portland cement further recognized cementitious materials such as Portland-slag cement and blastfurnace cement are produced [4]. In the UK, GGBS is manufactured and generally sold as a separate powder which is then batched and blended within the mixer. It is used extensively in the construction industry to produce concretes, grouts and mortars. Basically, slag is a mixture of lime, silica and aluminium which is the same element that makes up the Portland cement except with different proportion.

GGBS is off-white in colour like in Figure 3, which results in the production of a lighter mortar. This has an advantage when incorporating pigments, as the lighter colour results in improved colour depth and a potential reduction in the quantity of pigment required producing the desired colour. Data indicates that with high proportions of GGBS, pigment dosage may be reduced by approximately 20% without a discernible change in colour as measured by a spectrophotometer [15].

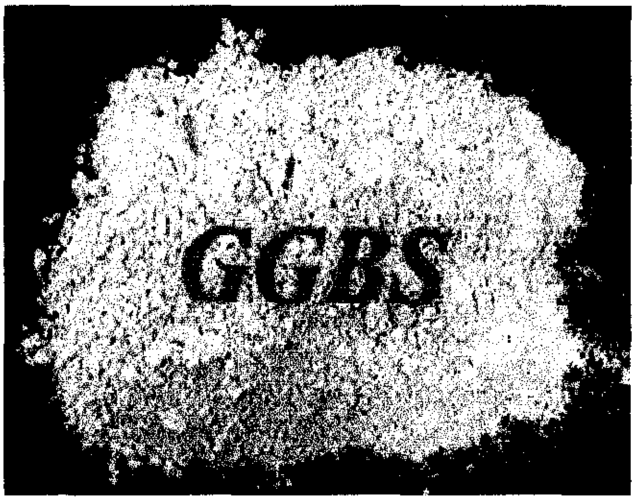


Figure 3: Ground granulated blast furnace slag

2.3 MIX DESIGN

Neville A.M. (2005, p.724) notes that in the British usage, the selection of the mix ingredients and their proportions is referred to as mix design. It is simply the process of choosing suitable ingredients of concrete and determining their relative quantities with the object of producing as economically as possible concrete of certain minimum properties, notably strength, durability and required consistency. In short word, mix design is selection of mix proportion of concrete.

The British approach, given in BS 5328: part 2: 1997 is to recognize four methods of specifying concrete mixes which are designed mix, prescribed mix, standard mix and designated mix. A designed mix is specified by the designer principally in terms of strength, cement content and water/cement ration, compliance relies on strength testing. A prescribed mix is specified by the designer in term of nature and proportions of mix ingredients. Standard mixes are used only in minor constructions such as house. Designated mix is limited in application to routine construction [4].

There are a lot of basic factors in the process of mix selection. The examples are minimum strength, thermal requirements, water/cement ratio, nature of cementitious materials, method of compaction and required workability. It can be seen then that mix selection requires both knowledge of the properties of concrete and experimental data or experience to select the most suitable mix proportion.

The requirements of BS 5328: Part 4: 1990 has indicated that following criteria must be satisfied:

(a) The average value of any four consecutive test results exceeds the specified characteristic strength by 3 Mpa (450 psi).
(b) No test result falls below the specified characteristics strength by more than 3 MPa (450 psi).
(c) Same requirements are prescribed for flexural test with values is 0.3 Mpa (45 psi).

2.4 COMPRESSIVE STRENGTH

Compressive strength is the primary physical property of concrete (others are generally defined from it), and is the one most used in design. It is one of the fundamental properties used for quality control for lightweight concrete. Compressive strength may be defined as the measured maximum resistance of a concrete specimen to axial loading. It is found by measuring the highest compression stress that a test cylinder or cube will support.

There are three type of test that can be used to determine compressive strength; cube, cylinder, or prism test. The 'concrete cube test' is the most familiar test and is used as the standard method of measuring compressive strength for quality control purposes (Neville, 1994). One of the example of the machine that been used for compressive strength test is Compression Machine 2000KN model ELE ADR 2000.

The specification of the machine is as in Table 1:

Overall dimensions (l x w x h)	
Load frame	430x430x1050
Control console	520x430x1255
Max vertical clearance	230 mm 340 mm
(platens removed)	
Max horizontal clearance	355 mm
Upper platen	300 mm dia
Lower platen	220 x 220 mm
Maximum ram travel	50 mm
Rated power	1600 W
Weight (total)	1460 kg

Table 1: Specification of Compression Machine 2000KN

CHAPTER 3
METHODOLOGY

3.1 PROJECT IDENTIFICATION

In order to attain the objectives been listed, this research will conducts 3 steps which are mixing, lab test and data analysis.

1. Mixing

   The mixing will be carried out regarding to the optimum mix design for foamed mortar in term of optimum density and w/c ratio, the optimum MIRHA, best setting up of the instruments, kind of loading will be applied, number of specimens, control and experimental grouping, testing procedure and recording.

2. Testing program

   The testing will be conducted in Civil Engineering Laboratory, UTP to analyze the actual strength and structural response of the block, failure/maximum load, deformation and strength characteristic and mode failure.

   Testing program will be conduct as below:

   a) Compressive Strength Test of Individual Block

      The main objective of this test is to obtain the compressive strength of each mix to see whether it can reach the required minimum compressive strength of 3.45 MPa. This test is done in accordance to BS EN 196-1: 1995.

   b) Splitting Tensile Strength Test

      This test is been done to see whether the mix design would fulfill the requirement of BS 5328: Part 4: 1990 indicated that tensile strength must be higher than 0.3 MPa.

   Both tests will be done using Compression Machine 2000KN model ELE ADR 2000.

3.2 EQUIPMENT

Portafoam Model LCM that the equipment that will be produced stable aqueous foam for the production of foamed mortar. Foam output volume – 100 to 150 lit / min. The Portafoam generators work by the uptake of premixed (diluted) chemicals from a pressurized tank which is delivered to a main unit (tank delivery). Tank delivery means that the premix solution (chemical concentrate + water) is placed in pressure tanks which deliver the premix to the main generating unit. Pressure tanks have limited capacity and therefore foam volume and delivery is limited to their size. The main unit consists of several gauges and valves (all pneumatic) and is responsible for the generation of stable foam. The stable foam is then delivered to a lance unit which further stabilizes the foam before it exits into the concrete mixer. However the problem arise in measuring the foam since the foam can't be compacted and for now, the measure is been done by estimating the volume of the foam.

Figure 4: Portafoam Model LCM

3.3 CONSTITUENT MATERIALS

The constituent materials used to produce floating foamed mortar are given in Table 2.

Materials	Remarks
Cement	Ordinary Portland Cement BSEN 197-1
MIRHA	It been made by burning the rice husk in incinerator and then been grained using Los Angeles abrasion machine
Foam	Preformed foam by aerating nature protein hydrolyzated based palm oil a ratio of 1:30 (by volume), aerated to a density of 70-80 kg/m3, ASTM C 869-91 (reapproved 1999), ASTM C 796-97
Silica Fume	It is in the densified form of micropellets
Ground granulated Blastfurnace slag	In a form of white fine powder

Table 2: Constituent materials used to produce foamed mortar

3.4 MIXING PROCESS

Chemical liquid those are diluted with water and aerated forming the foaming agent. The foaming agent used was nature protein hydrolyzated based palm oil consisting of hydrolyzed proteins and manufactured in Malaysia. Foamed mortar is produced in the laboratory with standard inclined rotating drum mixer according to BS 1881-125.1986 by the adding of pre formed foam to mortar. The density measured in accordance with BS EN 12350-6, weighing a foamed mortar sample in pre weigh container of known volume. A tolerance on plastic density was set at 70-80 kg/m3 of the target.

3.4.1 Mix Design for Foamed Mortar

Criteria for the foamed mortar are:-

- Density = 900kg/m^3 as maximum value
- Strength = 3 MPA as minimum value

<u>Mix design for 1m^3 of foamed mortar</u>

Target compressive strength at 28 days = >3.45 MPa

Water/cement ratio is 0.5

Target density = 900 kg/m^3

NC= 2400 k/m^3

Relative Density of Cement = 3.15

Relative Density= Density/ Density of Water

W/C ratio = 0.5

Weight of cement = 100 kg

Volume = Weight/ Relative Density

Volume of cement = 100 kg/3.150 = 31.75 m^3

Volume of water = 50kg/ 1 = 50 m^3

Total of cement, water and MIRHA = 81.75 m^3

For 1 m^3 Density (LCM)	1000	Liter
Cement=1000/(100x81.75)=	1223.30	kg
Water = 1000/(50x81.75) =	611.65	kg
TOTAL	1834.95	kg/m^3
Mortar Density	1834.95	kg/m^3
L/weight Density	900	kg/m^3

% Foam = [1- (900/1834.95)] x100= 51%

% Mortar = [1- 0.51]100 = 49%

Portion of Mortar = 49% of 1 m^3 = 490 liter

Portion of Foam = 51% of 1 m^3 = 510 liter

Foam agent (Fa)/water (w) = 1/30

Fa = w/30

Foam = (Fa+w) 22

= (1/30w + w) 22

w = (490/22)/ (1+1/30)

= 21.55 liter

Foam agent = 21.55/30

= 0.718 liter

3.4.2 Curing Stage

Curing is been done so that the hydration of mortar will be happened. The mortar is been cured in closed water tank at room temperature shown in Figure 5 so it can be protected from solar radiation and the high level of humidity can be maintained.

Figure 5: Mortar in water tank

3.5 CONCRETE TEST

This project will consist of testing of the mortar that been casted. For cube 100x100x100mm, three sample is been used and for cube 55x55x55mm, six samples is been used. The results would be taken as the average of samples. .

3.5.1 Compressive Strength Test

For this study, the compressive strength test was carried out on a mix of 100-mm and 55mm cube in compression testing machine conforming to BS 1881: Part 116. The compression strength machine that been used is Compression Machine 2000KN model ELE ADR 2000 shown in Figure 6.

Figure 6: Compression Machine 2000KN

3.5.2 Split Tensile Test

This test uses cylinder 200mmx100mm as its test sample. Instead of standing up in the loading machine, the cylinder lays on its side on cylinder holding shown in Figure 7. The size of the hardboard used in the cylinder holding is 4mm thick and 15mm wide as specified by BS 1881:117:1983. The machine that been used is Compression Machine 2000KN model ELE ADR 2000 .The machine will pushes down on the free side of the cylinder. The cylinder will split in two halves. Stress or tensile strength will be calculated by computer automatically and shown on the screen. Still, tensile strength of the concrete can be computed manually based on the load at which the cylinder split.

The equation is:

Tensile stress = $2P/(\pi)dL$

Where P: the load at which the cylinder failed

d: the diameter of the cylinder

L: is the length of the cylinder

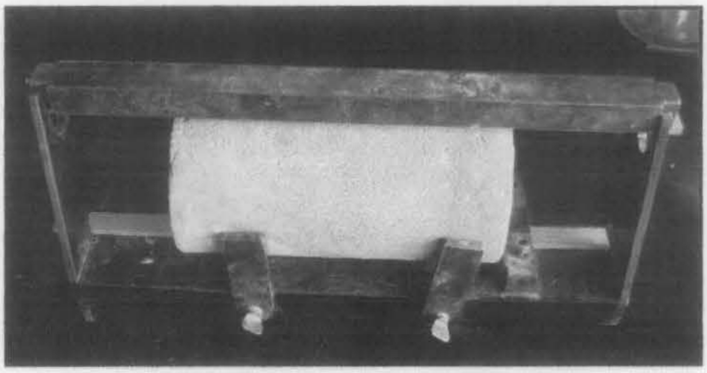


Figure 7: Cylinder Holder

Table 3 will show all the mix proportion that been designed and used in this study.

Code	MIRHA	Volume	Cement (kg/m3)	Cement (Kg)	MIRHA (kg/m3)	MIRHA (kg)	sand (kg/m3)	water (kg/m3)	water (kg)	foam (liter/m3)	foam (liter)	Density (kg/m3)	water correction (kg)
D9-0.4-0	0.00	28.32	600.00	16.99	0.00	0.00	0.00	300.00	8.50	509.52	14.43	**0.90**	7.86
D9-0.4-5	5.00	28.32	570.00	16.14	28.50	0.81	0.00	299.25	8.47	509.52	14.43	**0.90**	7.84
D9-0.4-10	10.00	28.32	540.00	15.29	54.00	1.53	0.00	297.00	8.41	509.52	14.43	**0.89**	7.78
D9-0.4-20	20.00	28.32	480.00	13.59	96.00	2.72	0.00	288.00	8.16	509.52	14.43	**0.86**	7.52

mix	Volume	w/c	MIRHA	SF	Slag	cement content	MIRHA	SF	Slag	Water	foam	total weight	Foam
3	12.13	0.5	10	10	20	4.85	485.20	485.20	970.40	3.39	10.18	0.84	6
5	9.82	0.5	10	10	0	3.92	0	392.85	0	2.16	6.48	0.66	6
7	10.81	0.5	10	0	20	4.32	432.71	0	865.42	2.81	8.43	0.78	6

Table 3: Mix design

3.6 HAZARD ANALYSIS

3.6.1 List of Hazard

Source of Hazard	Form of hazard	Area occurred
Mortar(chemical)	Exposure to the cement dust during weighting and mixing	Laboratory
Foam Agent(chemical)	Exposure to chemical splashes	Laboratory
Inclined rotating drum mixer	Mechanical rotation hazard, electrical hazard and noise hazard	Laboratory
Portafoam Model TM-2	Explosion and electrical hazard	Laboratory

3.6.2 Hazard Prevention

- Wear apron and lab coat
- Wear shoes and gloves
- Wear goggle and mask during handling the concrete
- Wear ear muffle during using mixing drum
- Obey the safety rules in laboratory

Figures 8 showed the safety equipments that provided and can be used in the concrete laboratory:

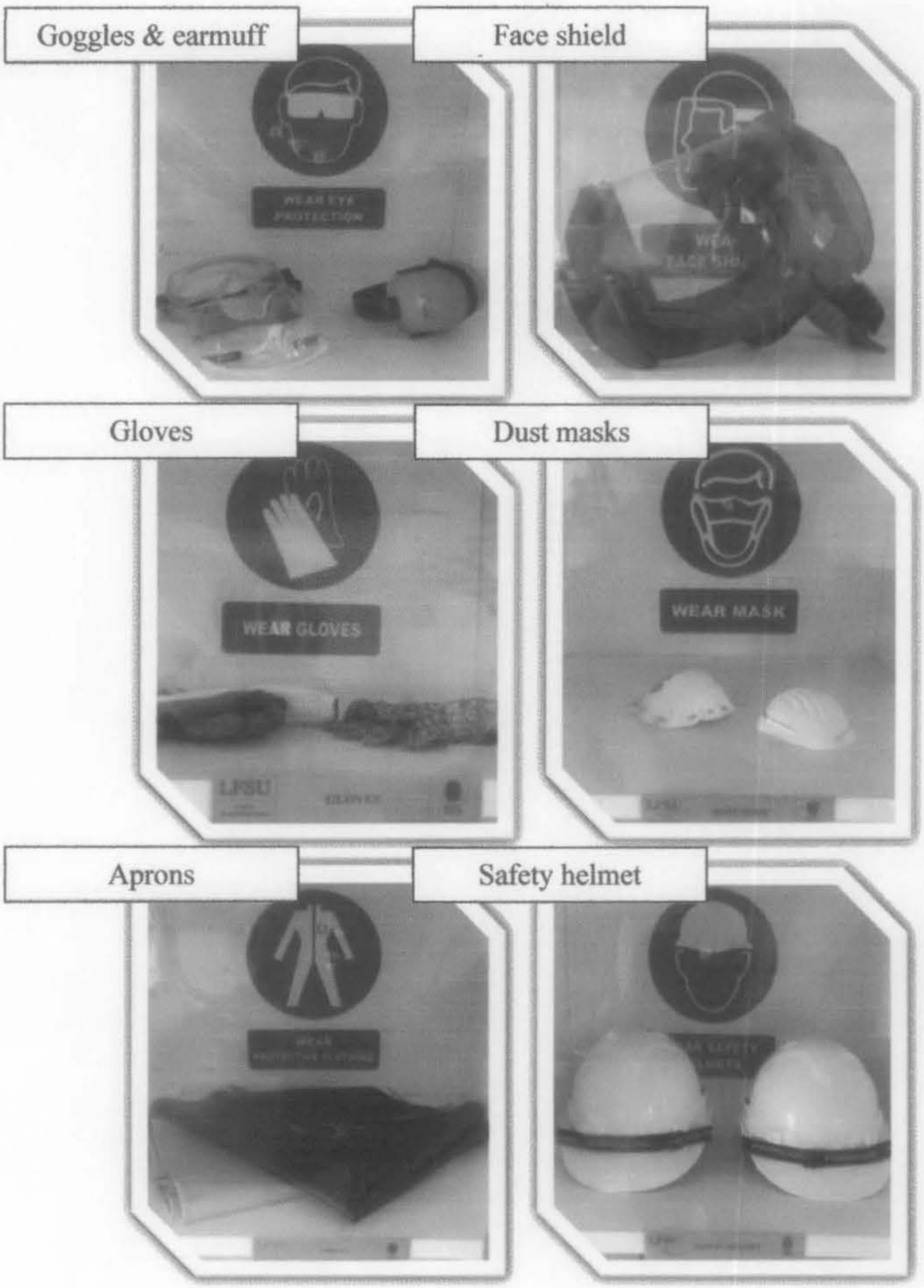


Figure 8: Safety equipment provided in the concrete lab

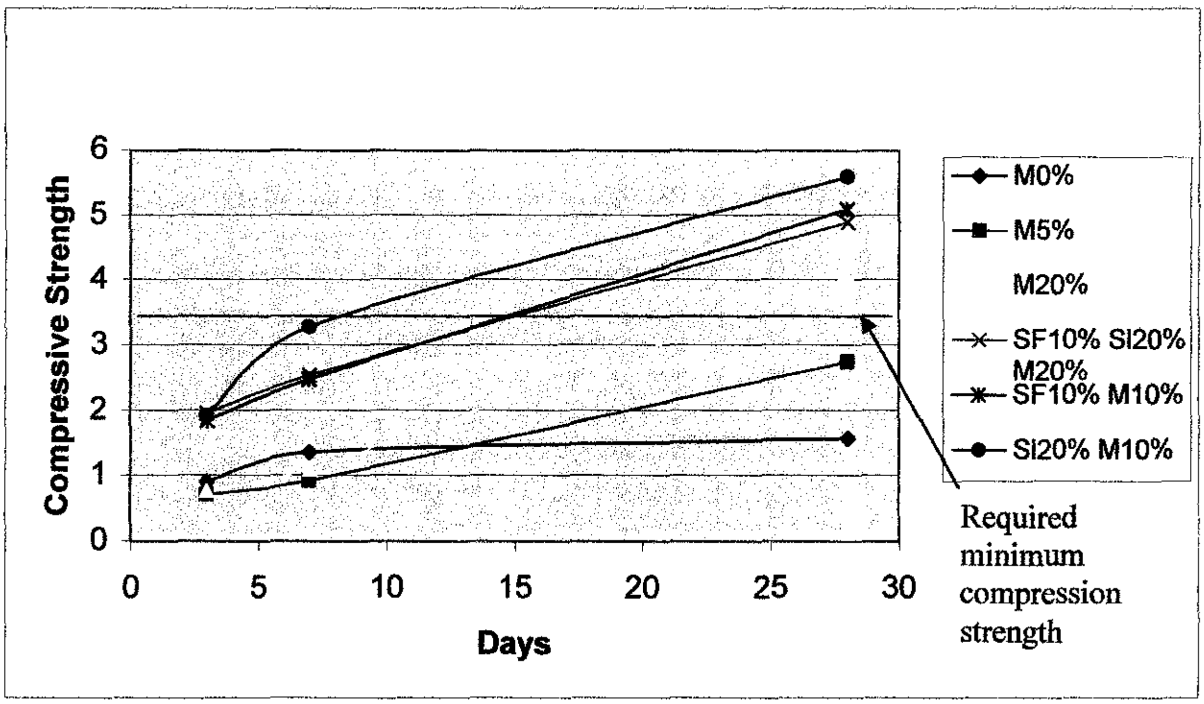
CHAPTER 4

RESULTS AND DISCUSSION

4.1 RESULT

Duration(days)	3rd		7th		28th	
	Density(kg/m³)	Stress(Mpa)	Density(kg/m³)	Stress(Mpa)	Density(kg/m³)	Stress(Mpa)
D9-0.5-0	641	0.91	660	1.36	769	1.58
	682	0.94	671	1.38	752	1.56
	651	0.92	672	1.38	721	1.51
D9-0.5-5	986	0.75	973	0.93	1072	2.72
	982	0.80	992	0.87	1096	2.84
	969	0.60	994	0.91	1101	2.88
D9-0.5-20	809	0.83	991	1.10	785	4.66
	816	0.76	984	0.94	762	4.06
	823	0.70	973	0.89	797	3.80
SF10-SL20-M10	983	1.93	1012	2.69	896	4.99
	962	2.15	1125	2.68	912	5.10
	975	1.95	1086	2.64	1000	5.13
SF10-SL0-M10	772	1.76	832	3.23	814	4.67
	808	1.85	744	2.41	885	5.10
	677	1.60	748	2.73	864	5.14
SF0-SL20-M10	908	1.86	920	3.72	941	5.51
	923	1.94	965	3.38	965	5.64
	942	1.74	967	3.13	984	5.71

Table 4: Test Result of Compressive Strength Test



Graph 1: Graph Compressive Strength vs Days

M0% - MIRHA 0%

SF10% - Silica fume 10%

SL 20% - Ground granulated blastfurnace slag 20%

From the Graph1, it can be conclude that all other mix design except control mix (M0%) and second mix (M5%) has managed to reach required minimum compressive strength at 28th days which is 3.45. The control mix is only able to reach compressive strength of 1.58 MPa in 28 days which is equal of 46% from required strength. For the second mix which is M5%, its 28th day's compressive strength also only reach up to 2.75 MPa which is 78% from required strength. For third mix (M20%), its 28th day's compressive strength has reached 4.04 Mpa which is surpassed the required strength by 17%. For the fourth mix, its 28th day's compressive strength is 4.9 MPa which also has surpassed required strength by 40%. For the fifth mix, its 28th day's compressive strength is 5.1 MPa that have exceeded required strength by 47%. Lastly the sixth mix also has managed to reach compressive strength of 5.6 MPa that exceeded required strength by 62% which is the highest compressive strength among the mixes.

Duration(days)	28	
	Density(kg/m³)	Stress(Mpa)
D9-0.5-0	641	0.18
	682	0.21
	651	0.20
D9-0.5-5	986	0.34
	982	0.28
	969	0.32
D9-0.5-20	809	0.67
	816	0.71
	823	0.88
SF10-SL20-M10	983	0.94
	962	0.92
	975	0.84
SF10-SL0-M10	772	0.74
	808	0.97
	677	0.88
SF0-SL20-M10	908	0.67
	923	0.87
	942	0.91

Table 5: Test Result of Split Tensile Test

The objective of split tensile test is fulfilling the requirement of BS 5328: Part 4: 1990 indicated that all mix must have minimum tensile strength of 0.3. So from the result, it is indicated that control mix and mix containing 5% MIRHA can't be used while other mix has managed to pass the requirement.

4.2 DISCUSSION

The sand also will not be included in the mix since it is been concluded that sand actually the cause of bursting air bubble. This has caused the previous mortar to have a big range of density between the cube for the same mix and reduced volume after 24 hours. The other parameters are also constant. It is been decided that the water cement ratio is 0.5 and foam agent water ratio is 1/30 from the literature review.

From the graph, it is concluded that the control mix has not acquired the required minimum compressive strength. However with the addition of MIRHA has helped the mortar to reach required strength. The mix of MIRHA and other pozzolan material also has reached the required strength and even manage to help increase strength of mortar even in early days. For the mix that contains MIRHA, it has lower early strength but higher 28 days strength compare to the control mix. For the tensile strength, all mix except for control mix has passed the requirement of minimum tensile strength of 0.3 MPa which is accordance to BS 5328: Part 4: 1990.

However several problems have been identified for this mixing. First, the density of each block for the same mix is inconsistent. The example like for the mixing that has target density of 700 kg/m^3 will produce the blocks that have density ranged from 500 to 800 kg/m^3. The second problem is the material which is Portland cement is damaged cause of over exposure of air. This has causing delay in the work. This is also the reason why for mix design using 10% MIRHA doesn't have test result since the damaged material has been used.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Several changes has been made in mix design and mixing process to improve the strength of the foamed mortar. As the result, the foamed mortar has managed to stay float in the water and at the same time, the objective of reaching the compressive strength of 3.45 MPa also has achieved with the exception for 2nd mix where the MIRHA percentage is too low to have any effect on the mortar.

This also has proved that addition of MIRHA would increase the strength of the mortar for the later stage strength compared the usual foamed mortar mix. However the addition of MIRHA will make the early strength lower than usual. The mix of MIRHA and other pozzolanic material also has increase the compressive strength at not only in 28 days but also at early days like in 3 days and 7 days.

5.2 RECOMENDATION

There are some recommendations in order to improve the research

i. The placing of mould will be protected from hot wind that coming from opened door that can caused the bubble of the foam to blow.
ii. The test would be done for 56 days and 90 days since the pozzolanic reaction from MIRHA is a slow process and its effect on the strength of the mortar takes longer time than usual mortar and only be able to be seen in 56 and 90 days.

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