PULVERIZED FLY ASH (PFA), SILICA FUME AND MICROWAVE INCINERATED RICE HUSK ASH (MIRHA) AS A MULTIPLE BINDER IN CONCRETE

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CIVIL ENGINEERING
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by

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Dissertation submitted in partial fulfilment of
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CERTIFICATION OF APPROVAL

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Approved by,

____
(Assoc Prof Ir Dr Muhd Fadhil Bin Nuruddin)

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.

MOHD AIZZAT BIN MOHD RAMLAN

ABSTRACT

The study deliberates on the incorporation of Microwave Incinerator Rice Husk Ash (MIRHA), Pulverized Fly Ash (PFA) and Silica Fume as a multiple binders to produce concrete. The mixes incorporating 5%, 7.5% and 10% MIRHA added with 10% PFA and 8% Silica Fume was prepared. The project objectives were to identify the optimum concrete mix proportion of binders containing Microwave Incinerated Rice Husk Ash (MIRHA), Pulverized Fly Ash and Silica Fume as concrete replacement material and also to establish the effect of MIRHA, PFA and Silica Fume on concrete properties. From the research that had been done, it's proved that 1 tons of Ordinary Portland Cement produces 1 tons of Carbon Dioxide (CO_2) emission. Beside that the usage of Portland cement can cause the environmental impacts at all stages of process in the industry. These include emissions of airborne pollution in the form of dust, gases, noise and vibration when operating machinery and during blasting in quarries, consumption of large quantities of fuel during manufacture, release of CO_2 from the raw materials during manufacture. Research also had proven that in Malaysia 100,000,000 tons of rice husks were thrown away as a waste product. By reusing it, this figure can be decrease; beside it also can decrease the usage of cement. It can be processed to be used as a binder in the concrete mix and also can reduce the pollutions. Several experiments had been determined to observe different properties of the concrete such as compression strength, surface hardness, Ultrasonic Pulse Velocity (UPV) and splitting tension test. From this project, it was observed that an addition of MIRHA 5 %, PFA 10 % and Silica Fume 8 % gave the optimal mixtures to get an optimal strength of the concrete. The same proportion also gave the optimum result for the tensile strength of the concrete. The different was about 14 % stronger than the normal concrete.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The project was aiming to identify the optimum concrete mix proportion of binders containing Microwave Incinerated Rice Husk Ash (MIRHA), Pulverized Fly Ash (PFA) and Silica Fume as concrete replacement material.

MIRHA is an active pozzolan that can be used to improve strength because they are smaller than the cement particles and can pack in between the cement particles by providing a finer pore structure. As we know, cement produces an excess of lime. So, by adding MIRHA which will combines with the lime and water, it will results in a stable and more resistance to the chemical attack. MIRHA can be used as a substitute to the cement while producing a more high strength concrete.

Silica Fume is also a reactive pozzolan that can be added to cement to improve the compressive strength, bond strength and abrasion of the concrete. It also can reduce the permeability of concrete to chloride ions which protects the reinforcing steel of concrete from corrode.

Pulverized Fly Ash is a mineral filler to fill the voids and provide contact points between the larger aggregate particles in concrete. Since it has a large uniformity coefficient consisting of silt-sized particles, it also can increase the workability of cement while reducing water demand.

1.2 Background of Study

Recently, many studies on the application of rice husk ash in the concrete have been carried out. This project was targeting to study on the performance of the concrete by adding rice husk ash, silica fume and pulverized fly ash as a multiple binder. The experiments were conducted to observe the strength of the concrete by using a different mixture and proportions of waste product. Several experiments had been determined to observe different properties of the concrete such as compression strength, ultrasonic pulse velocity test, surface hardness test and splitting tension test. The usage of the waste product has a lot of benefits since the cost of the product can be decrease and furthermore it can decrease the pollution to the environment. The final result of this project was aiming to get some output data that can prove whether the addition of the waste product into the concrete can enhance its performance and can be used as a cement replacement material.

1.3 Problem Statement

Ordinary Portland cement is the main material and has the most portions in the concrete mix because it is a basic ingredient of concrete, mortar, stucco and most non-specialty grout. The most important use of cement is the production of mortar and concrete which is the bonding of natural or artificial aggregates to form a strong building material which is durable in the normal environmental affects [1]. Although it is widely used there are still limitations exist on the usage of it.

The usage of Portland cement can cause the environmental impacts at all stages of process in the industry. These include emissions of airborne pollution in the form of dust, gases, noise and vibration when operating machinery and during blasting in quarries, consumption of large quantities of fuel during manufacture, release of CO_2 from the raw materials during manufacture. Cement is defined as a chemical material that formed from the predetermined ratios of reactants at fairly precise temperature. Ordinary Portland cement results from the calcinations of limestone and silica in the following reaction:

$$\textit{Limestone} + \textit{Silica} = \textit{Portland cement} + \textit{carbon dioxide}$$

From the research that had been done, it's proved that 1 tons of Ordinary Portland Cement produces 1 tons of Carbon Dioxide (CO_2) emission.

Besides that, the cost of using Ordinary Portland cement had increased day by day. These will affect the construction industry where cements are widely used. The price for one packet of cement of 50 kg nowadays is almost RM 17.00 compared to the previous year. Now days, a lot of high rise building has been built due to a limited space of development land. Most of high rise building use a lot of high strength concrete to withstand the load.

In addition, in the market now days, there is no proper binder exist to strengthen the concrete. So the writer want to propose a multiple binder that will be mix in the concrete proportions containing Pulverized Fly Ash, Silica Fume and Microwave Incinerated Rice Husk Ash. These materials can be used as a cement replacement material.

MIRHA is coming from the rice husk. Research had been proved that in Malaysia 100,000,000 tons of rice husks were thrown away as a waste product [2]. By reusing it, this figure can be decrease; beside it also can decrease the usage of cement. It can be processed to be used as the binder in the concrete mix and also can reduce the pollutions.

By using MIRHA also can cut the cost on the concrete mixing. Since MIRHA is a waste material, the production of it is much lower compared to concrete productions.

1.4 Objectives

The objectives of the project are:

a) To identify the optimum binder mix proportion in concrete containing MIRHA, PFA and Silica Fume.
b) To establish the effect of MIRHA, PFA and Silica Fume on concrete properties.

1.5 Scope of Study

The project was basically to determine the strength of the concrete when using the rice husk, silica fume and pulverized fly ash (PFA) as the multiple binders. Several types of samples had been determined for different tests. There were cubes and cylinders.

Samples sizes:

The cubes sizes were according to the standard where the dimensions are 150 mm x 150 mm x 150 mm. For the cylinder, the standard sizes was 150 mm of height with 150 mm of diameter

Number of samples:

The cube must have 9 samples where they had been used to test at the age of 3, 7 and 28 days (3 samples per day). The cylinder had 3 samples to be tested on 28 days.

Types of testing:

There were several tests that had been used to observe different properties of the concrete such as compressive strength, tensile strength, surface hardness and integrity of the samples. There were compression test, splitting tension test, rebound hammer and also ultrasonic pulse velocity (UPV) test.

The final result of this project was aiming to get some output data that can prove whether the addition of the waste product into the concrete can enhance the performance of it so that the usage of the cement can be decrease.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Concrete is used more than any other man-made material in the world. From the research that had been done, as of 2006, about 7 cubic kilometers of concrete are made each year which is more than one cubic meter for every person on Earth. There are many types of concrete available, created by varying the proportions of the water, aggregate, cement, sand and chemical admixtures. There are inorganic materials that also have pozzolanic or latent hydraulic properties. These very fine-grained materials are added to the concrete mix to improve the properties of concrete (mineral admixtures), or as a replacement for Portland cement.

Concrete are often mixed in improvised containers to have optimum mixing. There are three types of concrete which is Heavy weight Concrete, normal weight concrete and light weight concrete.

Current practice shows that Ordinary Portland Cement (OPC) is widely used as one of concrete ingredients. However, a problem that the construction industries have to overcome when using the OPC is the increase of carbon dioxide (CO_2) in air. The largest emissions from cement (actually clinker) manufacture is of CO_2, amounting to nearly 1 metric ton of gas per metric ton of clinker. About one-half of which is derived from the calcinations of calcium carbonate raw materials, and the rest, from the combustion of fuels.

2.2 Pozzolans

Most admixtures are pozzolans. A pozzolan is a powdered material, and added to the cement in a concrete mix reacts with the lime, released by the hydration of the cement, to create compounds which improve the strength or other properties of the concrete. By adding pozzolans it can improve the strength because they are smaller than the cement particles, and can pack in between the cement particles and provide a finer pore structure.

Pozzolans, such as fly ash and silica fume, are the most commonly used mineral admixtures in high-strength concrete. These materials can give additional strength to the concrete by reacting with Portland cement hydration products to create additional C-S-H gel, the part of the paste responsible for concrete strength [3]. Without using chemical admixtures, it would be difficult to produce high-strength concrete mixtures.

A wide variety of environmental circumstances such as reactive aggregate, high sulphate soils, freeze-thaw conditions, and exposure to salt water, de-icing chemicals, and acids are deleterious to concrete. A lot of researches and field experience has shown that the use of pozzolans is useful in countering all of these problems. The pozzolan is not just filler but a strength and performance enhancing additive. Pulverised fly ash and ground granulated blast furnace slag are the most common pozzolan materials for concrete.

2.3 Cement Replacement Materials (CRM)

There are many other cheaper and more abundant pozzolans available. A waste product from coal fired power stations is pulverised fly ash (PFA). It is abundant and cheap and is therefore often used as an admixture in high strength concrete. Ground granulated blast furnace slag produced from iron smelters is also highly pozzolanic and available. However, for high strength and quality, silica fume is preferred, for which RHA is a potential substitute.

Environmental issues that resulted from Portland cement production have made researchers to create advance methods to obtain materials that are sufficiently reactive to replace cement portion in concrete. These materials are generally a waste by-product and contain highly reactive silica to react with calcium hydroxide resulted from hydration process between cement and water.

Nowadays, there are a lot of wastes that have been found out to be the cement replacement material for OPC. The existing wastes that have been commercialized widely in construction industry are fly ash, silica fume, ground granulated blast furnace slag (GGBFS) and many more. These types of wasted was found out to have slightly the same characteristic with OPC which can be use as alternatives in replacing the OPC. Recently, rice husk ash has been studied as another material that can replace the OPC in producing concrete. RHA that is resulted from burning process of paddy husk is one of the cement replacement materials (CRM) produced from agriculture waste.

It is a very good approach in using these types of cement replacement material as to save the environment in order to reduce the wastage of these materials and also to lower the production of CO_2 in the air as the usage of OPC is reduced.

2.3.1 Microwave Incinerated Rice Husk Ash (MIRHA) as CRM

Microwave Incinerated Rice Husk Ash (MIRHA) is a strong choice for concrete strengthening. Recently, most research had used high cementations materials content that can give a desired properties to the concrete. Most mixtures contain one or more materials such as fly ash, ground granulated blast furnace slag, silica fume, metakolin or natural pozzolanic materials.

MIRHA is a product from the paddy that can be obtained with the combustion process of rice husk. It can be done by burning the rice husk in the incinerated microwave. The high content of amorphous silica and very large surface area make

MIRHA a highly reactive pozzolanic material that can be used to improve the strength and durability of concrete. Generally, reactivity of pozzolanic material can be achieved by increasing the fineness of the material.

There two main uses of MIRHA; as an insulator in the steel industry and as a pozzolan in the cement industry [4]. Substantial research has been carried out on the use of amorphous silica in the manufacture of concrete. There are two areas for which MIRHA are used; in the manufacture of low cost building blocks and in the production of high quality cement. Ordinary Portland Cement (OPC) is expensive and unaffordable to a large portion of the world's population. Since OPC is typically the most expensive constituent of concrete, the replacement of a proportion of it with RHA offers improved concrete affordability, particularly for low-cost housing in developing countries.

There are some researches that had been done and had proved the advantages of MIRHA:

- The addition of RHA speeds up setting time, although the water requirement is greater than for OPC.
- At 35% replacement, RHA cement has improved compressive strength due to its higher percentage of silica.
- RHA cement has improved resistance to acid attack compared to OPC, thought to be due to the silica present in the RHA which combines with the calcium hydroxide and reduces the amount susceptible to acid attack.
- More recent studies have shown RHA has uses in the manufacture of concrete for the marine environment. Replacing 10% Portland cement with RHA can improve resistance to chloride penetration.
- Several studies have combined fly ash and RHA in various proportions. In general, concrete made with Portland cement containing both RHA and fly ash has a higher compressive strength than concrete made with Portland cement containing either RHA or fly ash.

Research on producing the RHA that can be used in concrete is not a new finding. For example, Metha P.K had investigated the effect of pyroprocessing on the pozzolanic reactivity of RHA He established that burning rice husk under controlled temperature–time conditions produces ash containing silica in amorphous form [5]..

In the other research, Chopra, Ahluwalia and Laxmi have reported that for an incinerator temperature up to 700 °C the silica was in amorphous form. With that silica crystals grew with time of incineration. The combustion environment also affects specific surface area, and because of that temperature and environment also must be considered in the pyroprocessing of rice husks to produce ash of maximum reactivity [6].

Besides that, M.R.Yogananda and K.S.Jagadish from Indian Institute of Science (IISC), Bangalore, had also did several studies on the pozzolanic properties of rice husk ashes produced by different field incinerators [7]. From the experiment they had concluded that:

• Pre-grinding of RHA before intergrinding with lime is essential to achieve higher strength mortars.

• The long-term strength of RHA pozzolans produced from field arrangements in certain cases showed a decrease in strength after 28 days

Mauro M. Tashima, Carlos A. R. Da Silva, Jorge Akasaki and Michele Beniti Barbosa in their unknown date journal entitiled "*Possibility of Adding Rice Husk Ash to the Concrete*" also had made a research on the possibility of adding the Rice Husk Ash (RHA) to the concrete. Their research evaluates on how different contents of rice husk ash (RHA) added to concrete may influence its physical and mechanical properties of concrete. The properties such as simple compressive strength, splitting tensile strength, water absorption, and modulus of elasticity were determined and evaluated. As the result of the experiment, the use of RHA in construction, beside reducing the environmental polluters factors, it also can bring several improvement for the concrete characteristic such as decrease the water absorption and reducing on waste Portland cement [8].

Table 1 Water absorption test (%) [9]

Sample	Mixture of Cement (kg/m3)	7 days	28 days
D	490.0 (control item)	2.67	1.76
E	465.5 (5 % of RHA)	2.64	1.64
F	441.0 (10 % of RHA)	2.35	1.38

From the table it shows that higher substitution amounts results in lower water absorption because RHA is finer that cement.

Table 2 Simple compressive strength (MPa) [9]

Sample	7 days	28 days
D	45.9	48.1
E	52.9	60.4
F	45.8	54.2

The result from the table shows that the addition of RHA causes an increment in the compressive strength due to the capacity of the pozzolan, of fixing the calcium hydroxide, generated during the reactions of hydrate of cement.

Table 3 Splitting tensile strength (MPa) [9]

Sample	7 days	28 days
D	4.85	5.37
E	4.94	5.79
F	4.82	5.78

From the result, it approved that there was no interference of adding RHA in the splitting tensile strength.

As the conclusion from the research by Mauro M. Tashima, Carlos A. R. Da Silva, Jorge Akasaki and Michele Beniti Barbosa on the possibility of adding the Rice Husk Ash (RHA) to the concrete, it can give an effect on several properties such as water absorption and compressive strength.

In the other research by E.B Oyetola and M. Abdillahi, the writers try to determine the suitability of RHA as the added material to make the low-cost sandcrete block. To confirm the suitability for block making, preliminary analysis of the constituent materials of ordinary Portland cement and RHA hollow sandcrete blocks were conducted. From the experiment, test results indicate that the compressive strength for all mixes containing RHA increases when the age up. As a conclusion, RHA is available in significant quantities as a waste and can be utilized to make the sandcrete block [10].

Figure 1 Microwave incinerated rice husk ash (MIRHA)

Figure 2 Rice husk

Rice Husk Ash (RHA) is a byproduct of paddy that can be obtained with the combustion process of rice husk. The high content of amorphous silica and very large surface area make RHA a highly reactive pozzolanic material that can be used to improve the strength and durability of concrete. Generally, reactivity of pozzolanic material can be achieved by increasing the fineness of the material.

2.3.2 Silica Fume as CRM

There is also another binder that can be used to strengthen the concrete. It is Silica Fume. Silica fume can make a significant contribution to early-age strength of concrete. Silica fume improves concrete in two ways. There are by the basic pozzolanic reaction and a microfiller effect. By adding the silica fume, it can improve the bonding within the concrete and helps reduce permeability. It also can combines with the calcium hydroxide produced in the hydration of Portland cement to improve concrete durability.

As micro filler, the extreme fineness of the silica fume allows it to fill within the microscopic voids between cement particles. Since it has an extreme fineness and high silica content, silica fume is a highly effective pozzolanic material. The standard specification for Silica Fume that used in cementations mixture is ASTM C1240. Silica fume is added to Portland cement concrete to improve its properties, in particular its compressive strength, bond strength, and abrasion resistance.

In the nutshell, it can reduce permeability and improves the paste-to-aggregate bond of the resulting concrete compared to conventional concrete. Some of the advantages of Silica Fume are:

- Reduces concrete permeability
- Increases concrete strength
- Improves resistance to corrosion

From the paper work of *Guide to Silica Fume in Concrete* by American Concrete Institute, it had stated that before the mid-1970s, nearly all silica fumes were discharged into the atmosphere. After environmental concerns necessitated the collection and land filling of silica fume, it became economically justified to use silica fume in various applications, in particular high-performance concrete. The improvements resulting from addition of a very fine powder to the cement paste mix as well as from pozzolanic reactions between the silica fume and free calcium hydroxide in the paste [11].

From the research that had been done, the author find that Silica Fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles with a large surface area, and has a high SiO_2 content, silica fume can be a good binder to used in concrete.

Abdul Kareem in his journal had described on how mineral admixtures can develop the properties of concrete and it effects. They were three types of admixtures were used; fly ash, blast furnace slag and silica fumes. The admixtures had enhanced the properties of concrete significantly because of their spherical shape and small size of glassy particles. These admixtures can fill the void space between relatively large cement grains which is otherwise occupied by water [12].

In the water filled capillaries, the admixtures undergo pozzolanic reaction with Ca(OH) released during cement hydration. With that, the pore refinements that become as a larger size pores are transformed into smaller size pores.

Some properties of concrete can be affected by the admixtures such as workability, setting time, heat of hydration, air entrainment, hydration and strength development, effect of curing conditions on strength development, modulus of elasticity, drying shrinkage and creep, permeability, freeze-thaw durability and resistance to aggressive chemicals.

Table 4 Dosage of Silica Fume at different usage

8% to 15%	by weight of cement but *as an addition* not replacement.
8% to 10%	High durability / Low permeability such as bridge decks or parking structures
10% to 15%	High strength structural columns
10% max	Flatwork

The amount required is related to silica fume dosage and the water-cementitious materials ratio. Silica fume is cementitious, but typically is added to and not replacing the existing Portland cement. The higher percentage of silica fume used, the higher the amount of super plasticizer needed - but mix can become "sticky". Consider replacing about 1/3 of the super plasticizer with a mid-range water reducer to improve workability.

Silica fume is a waste product of the silicon metal and ferrosilicon industry [13]. The electrometallurgical processes involve the reduction of high purity quartz in electric arc furnaces at temperatures of over 2000°C. The silica fume is formed when SiO gas, given off as quartz reduces, mixes with oxygen in the upper parts of the furnace. Here the SiO is oxidised to SiO_2, condensing into the pure spherical particles of silica fume, forming the major part of the smoke or fume from the furnace. The silica fume is a super-fine powder of almost pure amorphous silica. The average particle size is 0.15 μ m in diameter, so every microsphere is 100 times finer than a cement grain.

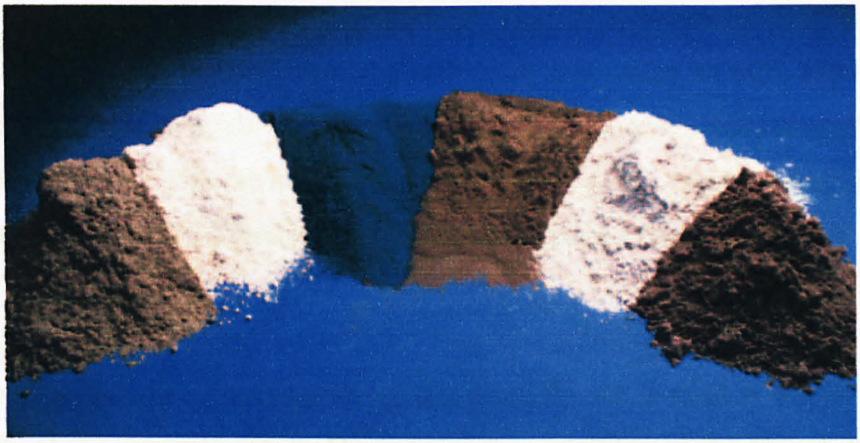


Figure 3 Different types of Silica Fume

2.3.3 Pulverized Fly Ash as CRM

Pulverized fuel ash (PFA) is used to describe the material extracted from the flue gases of coal-fired power stations via the use of electrostatic precipitators. Fly-ash can come in various size fractions (different collection "zones"), ranging from relatively coarse through to ultra fine material.

Fly ash, a siliceous material obtained from different thermal power stations is also being considered as a cementations ingredient for concrete. It is widely use nowadays since the usage of it by replacing the portion of the cement has a significant savings in cost production of concrete.

J. Paya, J. Monzo, M.V. Borrachero, E. Peris-Mora and E. Gonzalez-Lopez, in their research, had found from the experiment on mortars containing 15–60% fly ash as a replacement of Portland cement, it showed good correlation between strength and particle mean diameters when fly ash substitution was 60% [8].

In addition, high volume of fly ash (FA) can be used in self-compacting concrete (SCC) to produce high strength and low shrinkage. Properties included workability, compressive strength, ultrasonic pulse velocity (V), absorption and shrinkage had been done to prove the hypothesis.

Fly ashes are much more variable if want to compare with silica fumes in both their physical and chemical characteristics. Any fly ash which works well in ordinary concrete mixes is likely to work well in high strength concrete as well. However, most fly ashes will result in strengths of not much more than 70 MPa (70 N/mm^2), though there have been a few reports of high strength concretes with strengths of up to 98MPa (98 N/mm^2) in which fly ash has been used. For higher strengths, silica fume must be used in conjunction with the fly ash, though this practice has not been common in the past.

In general, for high strength concrete applications, fly ash is used at dosage rates of about 15% of the cement content. Because of the variability of the fly ash produced even from a single plant, however, quality control is particularly important. This involves determinations of the specific surface area, as well as the chemical composition (55.4% SiO_2, 25.5% Al_2O_3, 7.8% Fe_2O_3, 4.1% CaO, 1.0% MgO, 1.1% K_2O, 1.7%TiO_2 and some other chemical constituents).

Under normal conditions the pozzolanic reaction tends to proceed somewhat more slowly than the hydration of Ordinary Portland cement. Accordingly, all other things being equal, the use of fly-ash as a partial substitute for cement will generally result in a lesser rate of strength gain at early ages. Depending on the quantity of fly-ash involved and the details of the mix design, fly-ash concrete may still "lag" a little with respect to the standard 28-day strength measure but will usually catch up in the fullness of time. Note that is strength-lag feature can be offset in a large extent through appropriate adjustments to the concrete mix design (taking full advantage of the scope for a reduction in water demand brought by the use of fly-ash).

There are various improvements in concrete durability to be had from the inclusion of supplementary cementitious materials such as fly-ash. Concretes containing fly-ash tend to be somewhat less permeable (*tighter* paste structure) and show superior resistance to corrosion under mild-acid conditions. Fly-ash concretes are especially suitable for use in structures exposed to marine environments.

2.4 Effects of CRM Addition to the Concrete

2.4.1 Compressive Strength

A compression test determines behavior of materials under crushing loads. The specimen is compressed and deformation at various loads is recorded. Compressive stress and strain are calculated and plotted as a stress-strain diagram which is used to determine elastic limit, proportional limit, yield point, yield strength and, for some materials, compressive strength.

The compressive strength also can be understand as a measured by breaking cube or cylindrical concrete samples in a compression testing machine. It then calculated from the failure load divided by the cross sectional area resisting the load and reported in megapascals (MPa) in SI units. Strength test results from the samples maybe used for quality control, acceptance of concrete, for estimating the concrete strength in a structure and also for the protection afforded to the structure.

The compressive strength is shown in Table 5 and Figure 4. The addition of RHA causes an increment in the compressive strength due to the capacity of the pozzolan, of fixing the calcium hydroxide, generated during the reactions of hydrate of cement. All the replacement degrees of RHA increased the compressive strength. For a 5% of RHA, 25% of increment is verified when compared with mixture D.

Mixture	7 days	28 days
D	45.9	48.1
E	52.9	60.4
F	45.8	54.2

Table 5 Simple compressive strength (MPa) [9]

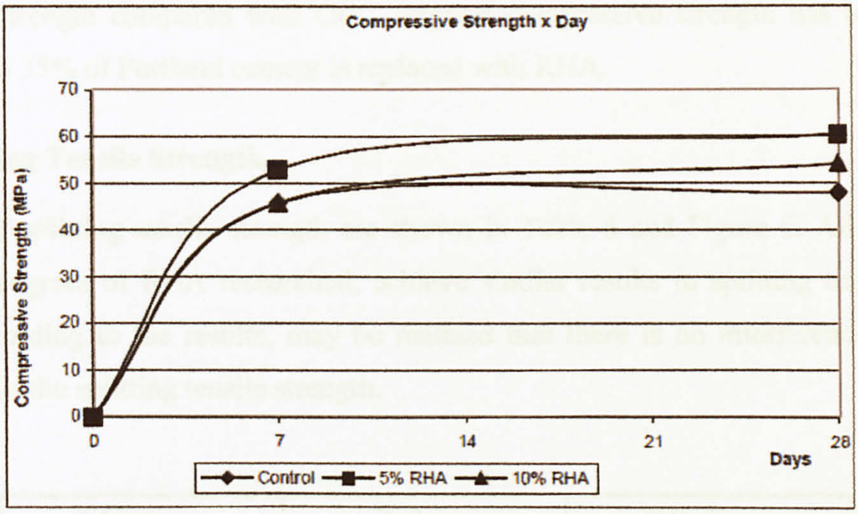


Figure 4 Results of compressive strength [9]

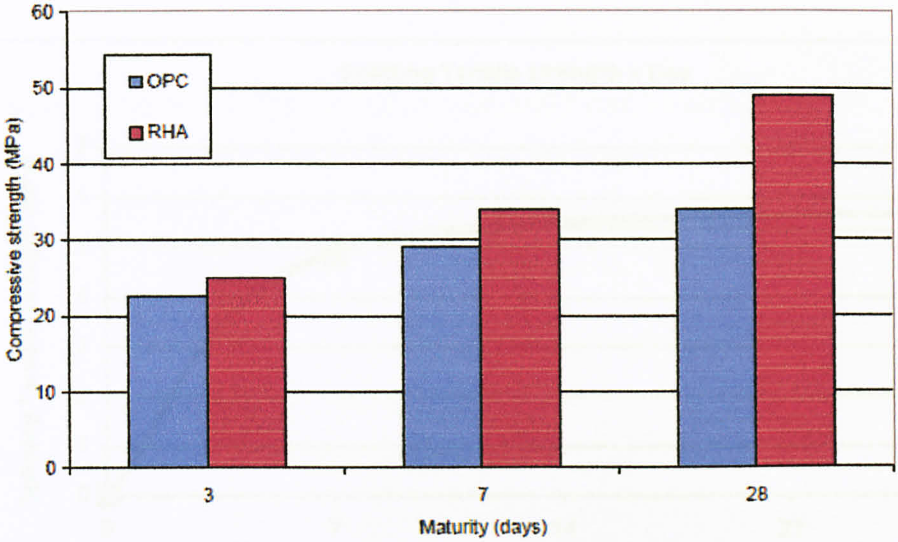


Figure 5 Compressive strength of RHA, cement and OPC [9]

Figure 5 compares the compressive strengths of OPC and RHA mortars. At 35 % replacement, the RHA cement had improved early strength and, due to its higher percentage of silica, the RHA cement also had a higher compressive strength at later dates. According to Owens, P. (1999), Pulverised Fuel Ash Part 1: Origin and Properties; shown that at 28 days RHA cement had significantly greater rates of compressive strength compared with OPC .Highest compressive strength has been obtained when 35% of Portland cement is replaced with RHA.

2.4.2 Splitting Tensile Strength

The results of splitting tensile strength are shown in Table 6 and Figure 6. All the replacement degrees of RHA researched, achieve similar results in splitting tensile strength. According to the results, may be realized that there is no interference of adding RHA in the splitting tensile strength.

Mixture	7 days	28 days
D	4.85	5.37
E	4.94	5.79
F	4.82	5.78

Table 6 Splitting Tensile Strength (MPa) [9]

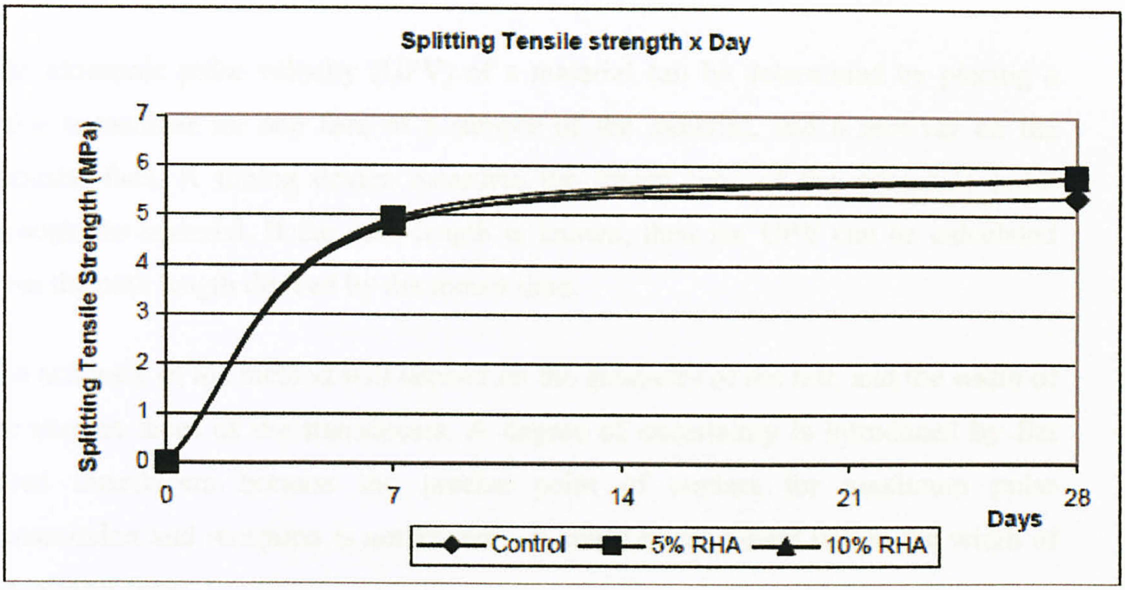


Figure 6 Results of Splitting Tensile Strength (MPa) [9]

The induced tensile stress state causes the specimen to fail by splitting. The maximum value of the tensile stress, computed at failure from the theory of elasticity, is the splitting tensile strength, f_{st}, ordinarily assumed in the standards to be a material property.

The main advantage of the splitting test is that the compressive loads are required. A cylindrical specimen of concrete is compressed along two diametrically opposed generators so that a nearly uniform tensile stress is induced in the loading plane. To prevent local failure in compression at the loading generators, two thin strips are placed between the loading platens and the specimen. It can be used to distribute the load.

2.4.3 Ultrasonic Pulse Velocity (UPV)

The velocity of an ultrasonic pulse through a material is a function of the elastic modulus and density of the material. The pulse velocity can therefore be used to assess the quality and uniformity of the material. The method is also useful for estimating crack depth and direction, and determining the thickness of surface layers damaged by chemical attack and fire.

The ultrasonic pulse velocity (UPV) of a material can be determined by placing a pulse transmitter on one face of a sample of the material, and a receiver on the opposite face. A timing device measures the transit time of the ultrasonic pulse through the material. If the path length is known, then the UPV can be calculated from the path length divided by the transit time.

The accuracy of the method will depend on the geometry of the test, and the width of the contact faces of the transducers. A degree of uncertainty is introduced by flat faced transducers because the precise point of contact for maximum pulse transmission and reception is not known - it could be anywhere within the width of the contact face.

The method is most accurate in direct transmission mode, where the transmitter and receiver are placed directly opposite each other on parallel faces of the test piece, and the path length can be measured or calculated with a high degree of accuracy. A lesser degree of accuracy is achieved when the test is applied on mutually perpendicular faces of the test piece, such as at a corner, due to the uncertainty of the true contact point. This is known as semi-direct transmission. The method is least accurate when both transducers are applied to the same face of the test piece, or indirect transmission. Also, the inaccuracy will be proportionally greater for shorter transmission path than for longer ones.

2.5 Incineration

MIRHA is burnt in the Modern incinerator to avoid environmental problem 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.

Incineration is the term usually used for deliberate combustion of husk without the extraction of energy and encompasses:

- open burning (such as deliberately setting fire to piles of dumped husk),
- Enclosed burning (typically a chamber made from fire resistant bricks with openings to allow air to enter and flue gases to leave).

The patent filed by P.K. Mehta, for producing RHA of a quality ideally suited to the cement market, describes burning the husk continuously at a low temperature to preserve the amorphous nature of the silica [5]. The method utilizes the fly ash after its separation from the flue gases by a multi cyclone separator. Commonly, in the production of highly amorphous ash, low temperatures and fairly long "burn times" are used, as for Mehta's patent.

Other work in India has also concentrated on this technique, and has shown how a two-stage process of combustion could control the chemical and physical properties of the resultant ash, increasing its pozzolanic activity by taking the husk through a carbonising process without "flaming" (Table 7). This type of burning was shown to produce a fine white ash which did not 'carbonize' By comparison; a "normal" combustion process (taking the furnace from room temperature up to the fixed burning temperature, where it was held until combustion was completed) produced a black coloured ash. This same study compared the RHA in terms of electrical conductivity and compressive strength tests.

		Temperature (°C)				
		<300	400	600	700	1000
Element (%)	Si	81.90	80.43	81.25	86.71	92.73
	K	9.58	11.86	11.80	7.56	2.57
	Ca	4.08	3.19	2.75	2.62	1.97
	Na	0.96	0.92	1.33	1.21	0.91
	Mg	1.25	1.20	0.88	0.57	0.66
	S	1.81	1.32	1.30	1.34	0.16
	Ti	0.00	0.00	0.00	0.00	0.45
	Fe	0.43	1.81	0.68	0.00	0.68
Oxide (%)	SiO_2	88.01	88.05	88.67	92.15	95.48
	MgO	1.17	1.13	0.84	0.51	0.59
	SO_3	1.12	0.83	0.81	0.79	0.09
	CaO	2.56	2.02	1.73	1.60	1.16
	K_2O	5.26	6.48	6.41	3.94	1.28
	Na_2O	0.79	0.76	1.09	0.99	0.73
	Fe_2O_3	0.29	0.74	0.46	0.00	0.43

Table 7 Chemical Composition of RHA under Different Burning Temperatures

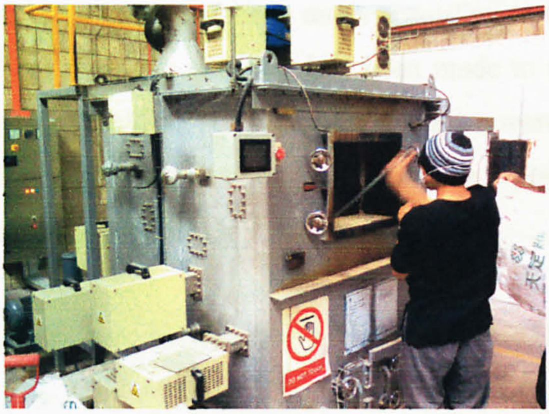


Figure 7 Microwave Incinerator

CHAPTER 3

METHODOLOGY

3.1 Project Work

To observe the strength development by using the combination of waste product between Rice Husk Ash (RHA), Pulverized Fly Ash (PFA) and Silica Fume (SF), some experiments had been determined. There were compression test, surface hardness test, integrity test and also splitting tension test.

3.2 Preparation of Concrete

There were several samples of concrete had been made according to the test that had been determined earlier. First, the plain concrete had been made to act as a control item. The grade of the concrete would be 70. The plain concretes were made with the combination of cement, sand, aggregate and water. There were 9 plain concrete had been made and to be test at the age of 3 days, 9 days and 28 days.

For the 2nd set of samples, there was combination of OPC and MIRHA. The amount of MIRHA were varies at 5%, 7.5% and also 10%. The portion of the mixture as per attached.

For the 3rd set, the concrete samples had a combination of OPC, MIRHA and also Silica Fume. The amount of Silica Fume had been locked to 8% since the previous research had been proved that it will react actively at that point. A sample of concrete that combined an OPC and Silica Fume (without MIRHA) also had been made to compare it with other samples. The mix proportions as per attached.

The 4th set of concrete samples combined the OPC, MIRHA and also Pulverized Fly Ash. The amount of PFA was locked at 10 % since from the previous research; it proved that PFA reacted actively at that point. The portions as per attached. The 5th samples of the concrete will have the combination of OPC, Silica Fume, PFA and also MIRHA. The portions are as per attached.

To determine all the properties of the concrete; cube and cylinder concrete had been made and had been tested on a different experiment.

The size for each type of concrete is as follows:

Table 8 Samples sizes of concrete

Concrete	Size (mm)
Cube	150 x 150
Cylinder	150 diameter x 150 height

The size are according the standard that determined by British Standard.

3.3 Compressive Strength Test

For the compression test, cube concrete had been used and was tested on the 3rd days, 7th days and 28th days. Before did the compression test, the cube was tested on UPV test and rebound hammer. Each test for certain days must have three samples of cube concrete and the average value had been determined.

A compression test was used to determine the behavior of materials under crushing loads. The test was done by compressing the specimen and the deformation of it will be determined at various samples and the result will be recorded.

3.4 Splitting Tensile Strength Test

For the splitting tensile test, a cylinder concrete had been used as the samples. The test was conduct at the age of 28 days. Three samples were used for the test and an average value had been taken.

The splitting tensile test was used to measure the tensile strength of concrete. The main advantage of the splitting test was that the compressive loads were required. A cylindrical specimen of concrete was compressed along two diametrically opposed generators so that a nearly uniform tensile stress was induced in the loading plane. To prevent local failure in compression at the loading generators, two thin strips were placed between the loading platens and the specimen. It can be used to distribute the load.

3.5 Burning Process

To get RHA, rice husk was burned in the incinerator oven with the temperature of 500°C. After the rice husk had been burned, it was then left for cooling and after that, had been burned again for the second time (2 cycles burning) with a same temperature. After got the rice husk ash, it then had been grinded in a grinder with 1500 rpm and then can be used in the concrete mixture.

The result for each properties of different mixture then had been compared to prove the hypothesis of the project. The comparison was used to determine which mixture gave a higher strength to the concrete.

3.6 Standard Test Method

3.6.1 Standard Test Method for Compressive Strength of Concrete

This test method covers the determination of strength of cylindrical concrete specimens that have been molded and cured in place using special molds attached to formwork for slabs. A concrete cylinder mold assembly consisting of a mold and a tubular support member is fastened within the concrete formwork prior to placement of the concrete. The elevation of the mold upper edge is adjusted to correspond to the plane of the finished slab surface. The mold support prevents direct contact of the slab concrete with the outside of the mold and permits its easy removal from the hardened concrete. Strength of cast-in-place cylinders may be used for various purposes, such as estimating the load-bearing capacity of slabs, determining the time of form and shore removal, and determining the effectiveness of curing and protection. Consolidation of concrete in the mold may be varied to simulate the conditions of placement. Internal vibration of concrete in the mold is prohibited except under special circumstances. A strength correction factor is required if the length-diameter ratio is less than 1.75.

Cast-in-place cylinder strength relates to the strength of concrete in the structure due to the similarity of curing conditions since the cylinder is cured within the slab. However, due to differences in moisture condition, degree of consolidation, specimen size, and length-diameter ratio, there is not a constant relationship between the strength of cast-in-place cylinders and cores. When cores can be drilled undamaged and tested in the same moisture condition as the cast-in-place cylinders, the strength of the cylinders can be expected to be on average 10 % higher than the cores at ages up to 91 days for specimens of the same size and length-diameter ratio.

Strength of cast-in-place cylinders may be used for various purposes, such as estimating the load-bearing capacity of slabs, determining the time of form and shore removal, and determining the effectiveness of curing and protection.

Figure 8 Compression machine

3.6.2 Splitting Tensile Strength of Cylindrical Concrete Specimens

This test method covers the determination of the splitting tensile strength of cylindrical concrete specimens. This method consists of applying a diametric compressive force along the length of a cylindrical specimen. This loading induces tensile stresses on the plane containing the applied load. Tensile failure occurs rather than compressive failure. Plywood strips are used so that the load is applied uniformly along the length of the cylinder. The maximum load is divided by appropriate geometrical factors to obtain the splitting tensile strength.

Figure 9 Tensile test setup

Figure 10 Specimen after fracture

The induced tensile stress state causes the specimen to fail by splitting. The maximum value of the tensile stress, computed at failure from the theory of elasticity, is the splitting tensile strength, f_{st}, ordinarily assumed in the standards to be a material property.

3.6.3 Pulse Velocity through Concrete

Pulses of compression waves are generated by an electro-acoustical transducer that is held in contact with one surface of the concrete under test. After traversing through the concrete, the pulses are received and converted into electrical energy by a second transducer located a distance L from the transmitting transducer. The transit time T is measured electronically. The pulse velocity is calculated by dividing L by T.

This ASTM test method covers the determination of the pulse velocity of propagation of compression waves in concrete. The pulse velocity V is related to the physical properties of a solid by the equation:

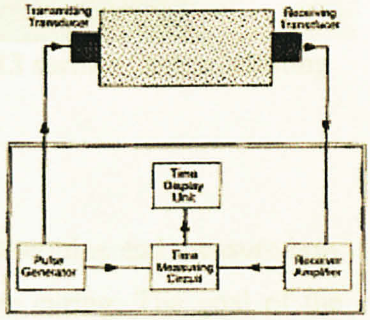


Figure 11 UPV

$$V^2 = (K)\frac{E}{\rho}$$

Where:

K = a constant,

E = the modulus of elasticity, and procedure

ρ = the mass density.

This test method does not apply to the propagation of other vibrations within the concrete.

3.6.4 Rebound Hammer

This test method is use to assess the in-place uniformity of concrete, to delineate regions in a structure of poor quality or deteriorated concrete, and to estimate in-place strength development. It also can be used to determine the surface hardness of the samples. To use this method to estimate strength development, it requires establishment of a relationship between strength and rebound number for a given concrete mixture.

This method use a steel hammer impact, with a predetermined amount of energy, a steel plunger in contact with a surface of concrete, and the distance that the hammer rebounds is measured.

Figure 12 Rebound hammer

Figure 13 surface hardness testing

3.6.5 Slump Test

Slump Test is an in situ test or a laboratory test used to determine and measure how hard and consistent a given sample of concrete is before curing. The goal of the Concrete Slump Test is to measure the consistency of concrete. Many factors are taken into account when satisfying requirements of concrete strength, and to make sure that a consistent mixture of cement is being used during the process of construction. The test also further determines the "workability" of concrete, which provides a scale on how easy, is it to handle, compact, and cure concrete [3].

Before starting the test be sure to start the test within 5 min after obtaining the final portion of the composite sample. When performing the test, first dampen the slump cone and place it on a flat, moist, nonabsorbent, rigid surface. The concrete then fill into the cone in three layers, each approximately one third of the volume of the cone from the composite sample obtained and while standing on the two foot pieces of the cone. In placing each scoopful of concrete, rotate the scoop around the top edge of the cone as the concrete slides from it to ensure even distribution of concrete within the mold. Tamp each layer with 25 strokes by the rod (using the rounded end), and uniformly distribute the strokes over the entire cross section of each layer. Tamp the bottom layer throughout its depth and also tamp the second layer and the top layer each throughout its depth so that the strokes just penetrate into the underlying layer. Remove excess concrete from the opening of the slump cone by using tamping rod in a rolling motion until flat. Slowly and carefully remove the cone by lifting it vertically (5 seconds +/- 2 seconds), making sure that the concrete sample does not move. Wait for the concrete mixture as it slowly slumps. After the concrete stabilizes, measure the slump-height by turning the slump cone upside down next to the sample, placing the tamping rod on the slump cone and measuring the distance from the rod to the original displaced center.

Figure 14 Slump test cone

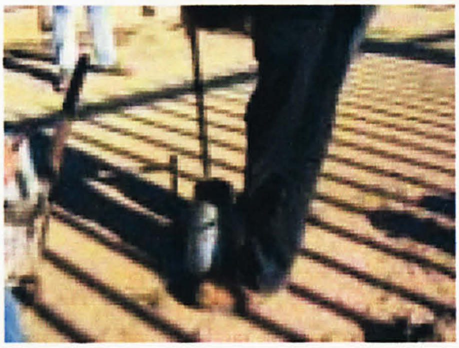


Figure 15 Concrete tamping

Figure 16 Slump measurement

CHAPTER 4

RESULT AND DISCUSSION

4.1 Results

The test result for compressive strength, tensile strength, surface hardness and integrity test for different characteristic of concrete were as follow:

Types		OPC	MIRHA	PFA	SF	Compressive Strength (MPa)		
		%	%	%	%	3 days	7 days	28 days
Normal concrete		100	0	0	0	33.10	50.64	69.51
OPC + MIRHA		95.0	5.0	0	0	37.32	56.71	77.19
		92.5	7.5	0	0	36.21	55.21	75.25
		90.0	10.0	0	0	34.24	53.70	73.20
OPC + MIRHA + PFA + SF	Set 1	82.0	0	10	8	51.34	67.16	81.27
	Set 2	77.0	5.0	10	8	60.26	70.71	86.53
	Set 3	74.5	7.5	10	8	57.61	67.60	84.22
	Set 4	72.0	10.0	10	8	55.36	59.13	84.14

Table 9 Result for compressive strength

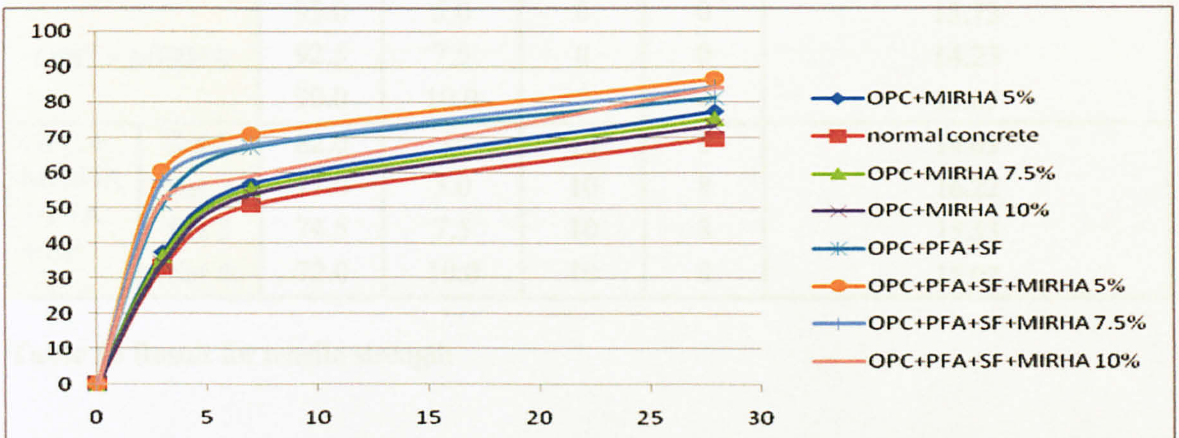


Figure 17 Graph of strength development for different characteristic of concrete (strength in Mpa vs age in days)

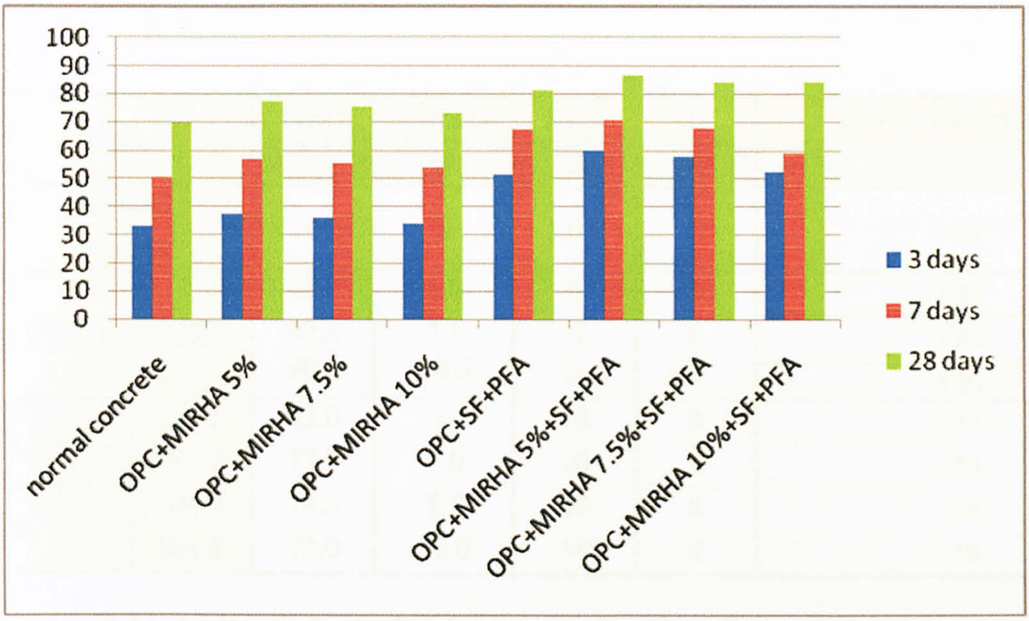


Figure 18 Bar graph of strength development for different characteristic of concrete (strength in Mpa vs age in days)

Types		OPC	MIRHA	PFA	SF	Tensile Strength (MPa)
		%	%	%	%	28 days
Normal concrete		100	0	0	0	15.58
OPC + MIRHA		95.0	5.0	0	0	15.73
		92.5	7.5	0	0	14.23
		90.0	10.0	0	0	13.65
OPC + MIRHA + PFA + SF	Set 1	82.0	0	10	8	14.65
	Set 2	77.0	5.0	10	8	16.22
	Set 3	74.5	7.5	10	8	15.53
	Set 4	72.0	10.0	10	8	15.02

Table 10 Result for tensile strength

Types		OPC	MIRHA	PFA	SF	Surface Hardness
		%	%	%	%	28 days
Normal concrete		100	0	0	0	110
OPC + MIRHA		95.0	5.0	0	0	130
		92.5	7.5	0	0	120
		90.0	10.0	0	0	120
OPC + MIRHA + PFA + SF	Set 1	82.0	0	10	8	120
	Set 2	77.0	5.0	10	8	140
	Set 3	74.5	7.5	10	8	130
	Set 4	72.0	10.0	10	8	110

Table 11 Result for surface hardness

Types		OPC	MIRHA	PFA	SF	Integrity
		%	%	%	%	28 days
Normal concrete		100	0	0	0	30
OPC + MIRHA		95.0	5.0	0	0	27
		92.5	7.5	0	0	29
		90.0	10.0	0	0	29
OPC + MIRHA + PFA + SF	Set 1	82.0	0	10	8	26
	Set 2	77.0	5.0	10	8	27
	Set 3	74.5	7.5	10	8	29
	Set 4	72.0	10.0	10	8	28

Table 12 Result for integrity test

4.2 Discussion

The data collected had been analyzed. As we can see in table 9, the strength of the concrete that had been added with the admixtures of MIRHA had a higher strength at the age of 28 days. There was also a different existed in the strength development of the concrete when additional mixtures of PFA and Silica Fume were added. The concrete with PFA and Silica Fume had a higher strength at the age of 28 days. So, it was proved that additional of mixtures had taken an effect on the concrete strength. It was because the pozzolanic reaction occurs between pozzolan materials; MIRHA, PFA and Silica Fume, with the Calcium hydroxide to produce a stronger C-S-H gel bonding. The optimum reaction as we can see from the table was when 5 % of MIRHA were added. Maybe at the excess amount of MIRHA; 7.5 % and 10 %, were added, it had made the reaction become slower and made the strength development slowly increased. From the table also we can observe that the concrete that had a mixtures of MIRHA 5 % that added with PFA and Silica Fume had the highest strength at the age of 28 days which was 86.53 MPa. So we can say this was the optimum admixture that can be used to have a stronger concrete. The different of this mixtures concrete with the normal concrete was about 14 %. The strength development of the concrete at also clearly shown in the graph (Figure 17 and Figure 18).

From table 10, the result for tensile strength was shown. It observed that from the table, at age 28 days, the concrete that added with MIRHA had a higher tensile strength compared to the normal concrete. The tensile strength optimum when 5 % of MIRHA were added. The tensile strength becomes stronger when additional admixtures of PFA and Silica Fume were added and the optimum value again when it contains 5 % of MIRHA which was 16.22 MPa.

The surface hardness of the concrete also different according the admixtures that added to the concrete. From table 11, it observed that concrete that added with MIRHA, PFA and Silica Fume can add strength to the concrete. It can be compared with the normal concrete. Same as the integrity of the concrete where the mixture in the concrete become well distributed since addition of MIRHA, PFA and Silica Fume strengthen the C-S-H gel bonding. The result can be seen in table 12.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From this project, it was observed that an addition of MIRHA 5 %, PFA 10 % and Silica Fume 8 % gave the optimal mixtures to get an optimal strength of the concrete. The same proportion also gave the optimum result for the tensile strength of the concrete. The different was about 14 % stronger than the normal concrete.

The effect of MIRHA, PFA and Silica Fume as a multiple binders on strength development of normal concrete has been determined from the compressive strength, tensile strength, surface hardness and integrity test. It can be said that MIRHA with additional of PFA and Silica Fume can be applied to concrete in some amount as to maintain the strength to the concrete and at the same time, reduce the usage of OPC as to solve the problem that has been stated at the early phase of the project.

5.2 Recommendation

As for recommendation, this multiple binders should be applying by the industries to solve the problems stated above and at the same time to produce cost effective structural concrete.

Besides that, another proportion of different admixtures also can be made to find which admixtures can be used in the concrete mixtures to increase the strength while decrease the usage of Ordinary Portland Cement.

REFERENCES

[1] Neville, A.M. 2000. Properties of Concrete. 4th ed. (low-price ed.). Pearson Education Asia Publ., England, produced by Longman Malaysia.

[2] Nur, Hadi and Ramli, Zainab and Endud, Salasiah and Hamdan, Halimaton and Sukowski, Bogdan (2006) *Conversion of rice husk ash to zeolite beta.* Waste Management, 26 (10). pp. 1173-1179.

[3] Cook D.J. (1986) Natural pozzolanas. In: Swamy R.N., Editor (1986) *Cement Replacement Materials*, Surrey University Press, p. 200.

[4] Chao Lung Hwang and Satish Chandra, 1997, 'Waste Materials Used in Concrete Manufacturing, Chapter 4 : The use of rice husk ash in concrete'.

[5] METHA, P. K. (1973), Rice husk ash – a unique suplementary cementing material, in: V.M.Malhotra (Ed), Proceedings of the International Symposium on Advances in Concrete Technology. CANMET/ACI, Athens, Greece, May, 1992, pp. 407-430.

[6] Deepa G Nair Alex Fraaij, Adri A.K. Klaassen and Arno P.M. Kentgens (2006), '*A structural investigation relating to the pozzolanic activity of rice husk ashes*'. Chapter 2 : Preparation of Rice Husk Ash.

[7] Yogananda M.R, Jagadish K.S and Kumar R (1983), '*Studies on Surki and rice husk ash pozzolona*', Alternative Buildings Series 9.

[8] PAYÁ, J. et al. Studies om cristalline rice rusk ashes and activation of their pozzolanic properties. In WOLLEY, G. R.; GOUMANS, J. J. J. M.; WAINWRIGHT, P. J.. Waste materials in construction wascon 2000. Amsterdam: Pergamon, 2000. p.493-503. (Waste Management Series, 1).

[9] Mauro M. Tashima, Carlos A. R. Da Silva, Jorge Akasaki and Michele Beniti Barbosa (2003), "*Possibility of Adding Rice Husk Ash to the Concrete*".

[10] Oyetola E. B. and Abdullahi M. (2006), 'The Use of Rice Husk Ash in Low - Cost Sandcrete Block Production, Chapter 2 : p. 3

[11] '*Guide for the Use of Silica Fume in Concrete*', American Concrete Institute , ACI 234R-06 supersedes ACI 234R-96 (Reapproved 2000) and became effective April 13, 2006.

[12] Kareem A. (2007), '*Effect of mineral admixtures on properties of concrete*'

[13] Detwiler, R.J. and Mehta, P.K., *Chemical and Physical Effects of Silica Fume on the Mechanical Behavior of Concrete*, November 1989,

APPENDICES

Appendix A: Materials used for the project

Cement

MIRHA

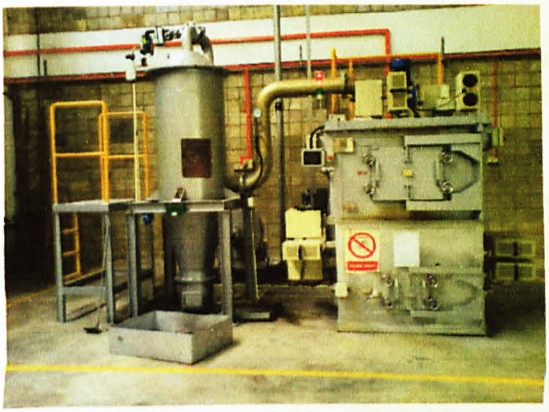
Sand

Water with super plasticizer

Appendix B: Equipment used in the project

Concrete Mixer

Compression Testing Machine



Microwave Incinerator

Grinding Machine

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MIXING AND SAMPLING FRESH CONCRETE

1. OBJECTIVE

Mixing and sampling fresh concrete in the laboratory (as recommended by **BS 1881: Part 125:1986)**

2. APPARATUS

A non-porous timber or metal platform, a pair of shovels, a steel hand scoop, measuring cylinder and a small concrete mixer (if machine mix)

3. *PROCEDURE*

a. Weight the quantities of cement, sand and course aggregate to make 1:2:4 concrete mix at water ratio of 0.6

b. Hand Mixing

   i. Mix cement and sand first until uniform on the non-porous platform
   ii. Pour course aggregate and mix thoroughly until uniform
   iii. Form a hole in the middle and add water in the hole. Mix thoroughly for 3 minutes or until the mixture appears uniform in color.

c. Machine Mixing

   i. Wet the concrete mixer.
   ii. Pour aggregate and mix for 25 second.
   iii. Add half of water and mix for 1 minute and leave for 8 minutes.
   iv. Add cement and mix for 1 minute.
   v. Add remaining water available and mix for 1 minute.
   vi. Stop the machine and do hand mixing to ensure homogeneity.
   vii. Pour out the concrete onto the non porous surface.

4. PRECAUTIONS

a. The room temperature should be approximately 25-27 C

b. Make sure that fine and aggregate are dry. If they are wet find the content of the aggregates to determine the quantity of water required.

Appendix C: Lab manual for compressive strength test

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COMPRESSIVE STRENGTH TEST CUBES – TEST FOR STRENGTH

1. OBJECTIVE

To determine the compressive strength (Crushing strength) of concrete according to **BS 1881: Part 116: 1983**

2. THEORY

One of the most important properties of concrete is its strength in compression. The strength in compression has a definite relationship with all other properties of concrete. The other properties are improved with the improvement in compressive strength.

The compressive strength is taken as the maximum compressive load it can be carry per unit area. Compressive strength tests for concrete with maximum size of aggregate up to 40mm are usually conducted on 150mm cubes.

3. APPARATUS

Compression Testing Machine (it complies with the requirement of **BS 1610**)

4. PROCEDURE

a. Remove the specimen from curing tank and wipe surface water and grit off the specimen.

b. Weight each specimen to the nearest kg.

c. Clean the top and lower platens of the testing machine. Carefully center the cube on the lower platen and ensure that the load will be applied to two opposite cast faces of the cube.

d. Without shock, apply and increase the load continuously at a nominal rate within the range 0.2N/mm^{2}s to 0.4 N/mm^2 until no greater load can be sustained. Record the maximum load applied to the cube.

e. Note the type of failure and appearance of cracks.

f. Calculate the compressive strength of each cube by dividing the maximum load by the cross sectional area. Express the results to the nearest 0.5 N/mm^2

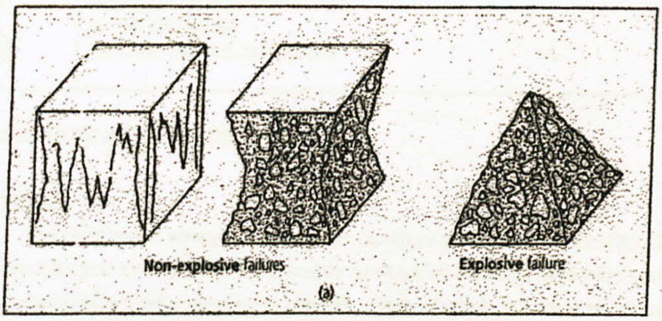

FIGURE 5: The outcome of cube test – normal case

Appendix D: Lab manual for Ultrasonic Pulse Velocity (UPV) Test

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ULTRASONIC PULSE VELOCITY TEST (UPV)

1. OBJECTIVE

The UPV test is designed to study the quality of the concrete in existing structures. It also can be used to determine the dynamic modulus of elasticity, dynamic Poisson's ratio, homogeneity, estimated compression strength, depth of crack, thickness of damaged layers and density of concrete. Fire damaged structures can also be assessed using this non destructive testing technique. Test done using the UPV test technique conforms to **BS 1881: Part 201:1986** "*Non-Destructive*" methods of test for concrete measurement of the velocity of ultrasonic pulses in concrete.

2. APPARATUS

A pulse of longitudinal vibrations is generated by an electro-acoustical transducer (transmitter) and received by a similar receiver which is placed on the opposite side of the concrete member under test. The time taken (transmit time) for the pulse of vibration to travel between the transmitter and receiver when divided by the transmit time (t) gives the pulse velocity, V = L/t

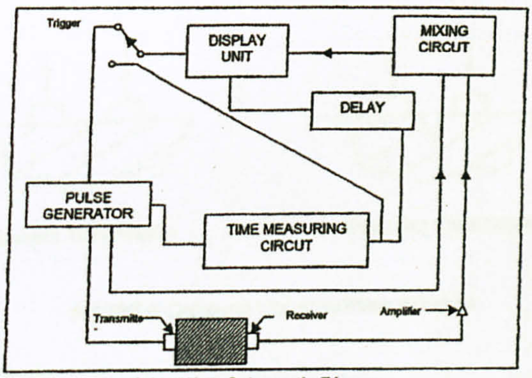

FIGURE 7: Schematic Diagram

3. PROCEDURE

a. Labeled the faces of the concrete cube with A, B, C, D, E and F

b. Make sure that A and B are place on the opposite faces.

c. The same rule applies to C,D ,E and F

d. Use of a coupling gel between the transducer and the concrete cubes or structures.

e. The transmitting and receiving transducers are placed on opposite surfaces of the concrete cube.

f. Push the transmitting and receiving transducers as strong as possible.

g. Take the lowest reading measured by UPV device

4. METHOD

The equipment (PUNDIT) used to determine the Ultrasonic Pulse Velocity in concrete consists of a transducer, receiver and the Main Control Unit. Different arrangements to determine ultrasonic pulse velocities are possible when testing concrete members for quality. Depth of cracks in test members can be determined by placing the transducers across the crack as shown in figure below.

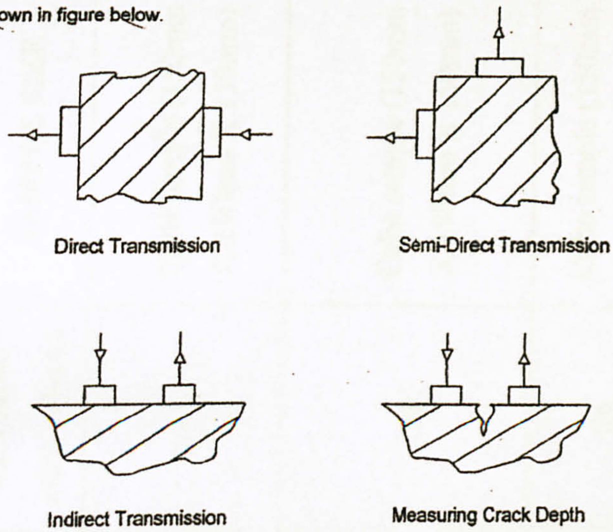

FIGURE 8: Determine Ultrasonic Pulse Velocities

Experimental detail

TEST TYPE	EQUIPMENT	TESTING AGE - day(s)	SAMPLE SIZE	NO. OF TEST	MEASUREMENT UNIT
Compression Test	Compressive Strength Test Machine	3,7, 28	Cube sample (150mm X 150mm X 150mm)	3 samples of each day test.	N / mm^2
Integrity Test	Ultrasonic Pulse Velocity Testing Machine	28	Cube sample (150mm X 150mm X 150mm)	3 samples of each day test.	µs
Surface Hardness	Rebound Hammer	28	Cube sample (150mm X 150mm X 150mm)	3 samples of each day test.	N / mm^2
Splitting Tension Test	Compressive Strength Test Machine	28	Cylinder sample (150mm of height with 150mm of diameter)	3 samples of each day test.	mm-kg