Burning Procedure of Rice Husk and the Influence of Rice Husk Ash on Concrete

By

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CERTIFICATION OF APPROVAL

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Civil Engineering Programme
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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.

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ABSTRACT

This report deals with the evaluation of the influence of burning procedure to the quality of rice husk ash. Rice hush ash (RHA) has a pozzolanic reactivity characteristic which can be used to partially replace the cement content. The rice husk ash used is obtained from controlled auto combustion of rice husk in a closed chamber with control burning temperature. The understanding on the effect of RHA on the rheology and workability of fresh concrete is important because RHA can impact the strength and durability of hardened concrete.

The project focuses on identifying the effect of RHA on workability of the concrete and the optimum inclusion of RHA in concrete. Several types of burning RHA are done and tested to know the composition of silicon dioxide, SiO_2 contained in the RHA and its influence on the strength of concrete.

This research work also evaluates how different contents of rice husk ash (RHA) added to concrete may influence its fresh concrete properties. Samples with dimensions of 15 x 15 x 15 cm are tested, with 5%, 10% and 15% replacement of cement with RHA. The results show that in general, for similar w/c ratio (0.40), the replacement of 15% of the portland cement by the RHA affect significantly the compressive strength but has no significant effect on the workability. The results are compared to the control sample and the viability of adding RHA to concrete is verified.

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Rice husk is an agro-waste material which is produced in the order of 100 million tons annually. Approximately, 20 kg of rice husk are obtained for 100 kg of rice. Rice husks contain organic substances and 20% are of inorganic material. [Wainwright, P.J. 2000]. Rice husk ash (RHA) is obtained by the combustion of rice husk. The most important property of RHA that determines pozzolanic activity is the amorphous phase content. RHA is a highly reactive pozzolanic material suitable for use in lime-pozzolana mixes and for Portland cement replacement. RHA contains a high amount of silicon dioxide, and its reactivity related to lime depends on a combination of two factors, namely the non-crystalline silica content and its specific surface.

Research on producing rice husk ash (RHA) that can be incorporated to concrete and mortars are not recent. In 1973, a research has been done on the effect of pyroprocessing on the pozzolanic reactivity of RHA [Mehta, P.K. 1992]. Since then, a lot of studies and also researches have been developed to improve the mechanical and durability properties of concrete.

Such ashes, suitably ground, have been used as cement replacement materials. In view of the large quantities of rice husk ash produced such use has naturally been widely investigated. More recently there has been investigation of the potential for the production of high strength mixes incorporating finely ground ash [Alexander, M.G. 1999].

1.2 Problem Statement

Rice hush ash (RHA) is an agro-waste material which is produced in a large amount per year. It polluted the ground where it is dumped. Disposal has become a challenging problem. It is recognised that only the cement and concrete industries can consume such large quantities of solid pozzolanic wastes. The RHA has high pozzolanic reactivity because it has cementitious material like silica dioxides, which can be used to partially replace the cement content. Using it as a cement replacement material is cost-effective since the RHA is a waste material. Furthermore, from the previous researches, the concrete with RHA produced higher strength and durability compared to normal concrete.

1.3 Objectives of Project

The objectives of this project are listed such as below:

- To identify the effect of RHA on workability
- To establish the optimum inclusion of RHA in concrete
- To establish a burning procedure that can enhance the integrity of RHA.

1.4 Scope of Work

This project covers the production of RHA using microwave incinerator. A set of mix proportion with 0, 5, 10, and 15% inclusion of RHA is employed. These mix proportion are then adopted with different w/c ratio namely 0.35, 0.4 and 0.45. Several tests are done onto the fresh and hardened concrete. Vebe, slump, and compacting factor tests are done on the fresh concrete whilst compressive strength and UPV tests are conducted later on the ages of 3, 7, and 28 days.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction of Rice Husk Ash

Rice milling generates a by product know as husk. This surrounds the paddy grain. During milling of paddy about 78 % of weight is received as rice, broken rice and bran. Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk contains about 75 % organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the combustion process, is known as rice husk ash (RHA).

India is a major rice producing country, and the husk generated during milling is mostly used as a fuel in the boilers for processing paddy, producing energy through direct combustion and or by gasification. About 20 million tones of RHA are produced annually. The current world production of rice paddy is around 500 million tons and hence 100 million tons of rice husks are produced [Mehta,P.K.]. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped. Lots of ways are being thought for disposing them by making commercial use of this RHA.

The particle size of the cement is about 35 microns. There may be formation of void in the concrete mixes, if curing is not done in properly. This reduces the strength and quality of the concrete. RHA is much finer than cement having very small particle size of 25 microns, so much so that it fills the interstices in between the cement in the aggregate. That is where the strength and density comes from. And that is why it can reduce the amount of cement in the concrete mix.

RHA is a super-pozzolans. It can be used in a big way to make special concrete mixes. There is a growing demand for fine amorphous silica in the production of special cement and concrete mixes, high performance concrete, high strength, low permeability concrete, for use in bridges, marine environments, nuclear power plants etc. This market is currently filled by silica fume or micro silica, being imported from Norway and also from Burma due to limited supply of silica fumes in India and the demand being high the price of silica fume has risen to as much as US$ 500 / ton in India. [Narayan, P.S. 2004]

RHA has the potential to be used as a substitute to silica fumes or micro silica at a much lower cost, without compromising on the quality aspect. Adding RHA to the concrete mix even in low replacement will dramatically enhance the workability, strength and impermeability of concrete mixes, while making the concrete durable to chemical attacks, abrasion and reinforcement corrosion, increasing the compressive strength by 10 % - 20 % [Narayan, P.S. 2004].

RHA has excellent water resistance (impermeability) properties and is used in waterproofing compounds to give amazing results. It reduces the water penetration by as much as 60 % of the water needed in concrete mix. Adding RHA to concrete and paints helps to reduce the chloride ion penetration by as much as 50 % into the marine structure, thus improving life of the building. Adding RHA to the concrete also lowers the heat of hydration by as much as 30 % and prevents formation of cracks during casting [UK - ICT News 55 - Nov Edition]. In this following chapter, the characteristics, quality, and influence of rice husk ashes on the quality of concrete are discussed.

2.2 Classification of Rice Husk Ash

The chemical composition of rice husk is similar to that of many common organic fibers and contains: a) cellulose ($C_5H_{10}O_5$), a polymer of glucose, bonded with B-1.4, b) lignin ($C_7H_{10}O_3$), a polymer of phenol, c) hemicellulose, a polymer of xylose bonded with B-1.4 whose composition is like xylem ($C_5H_8O_4$), and d) SiO_2, the primary component of ash. The holocellulose (cellulose combined with hemicellulose) content in rice husk is about 54% [Lin, K.M.1975], but the composition of ash and lignin differ slightly depending on the species, as shown in Table 1. The critical composition of rice husks from different species also varies slightly [Yand. S. J. 1980 and Anderson, L. L. 1977].

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 micro porous 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 [Mehta, P. K.1992].

Table 1 Chemical composition of rice husks

Rice Husk	**Extractives**			**Chemical Composition (%)**		
	Alcohol-benzene	**1% NaOH**	**Hot Water**	**Holo-cellulose**	**Ash**	**Lignin**
Japonica	1.8	32.3	5.4	53.9	13.6	24.8
Indica	2.1	30.6	5.1	54.3	11.7	25.8
Anhydrous Rice Husk	-	-	8~15	40~50	15~20	25~30

2.2.1 The Effect of Burning Temperature

Table 2 below shows the chemical composition of the RHA at different temperatures:

Table 2 Chemical compositions of RHA under different burning temperatures

		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	1.66
	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	3.64	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

Burning temperature has significant effects on the quality of RHA;

a) At 400°C, due to transglycosylation[1], polysaccharides begin to depolymerize, producing levoglucosan, monosaccharide derivatives, and oligosaccharides.
b) Dehydration of the sugar units occurs above 400°C producing 3-deoxyglucosenone, levoglucosenone, funicular and furan derivatives.
c) At 700°C, the sugar unit decomposes, producing some cabby compounds such as acetaldehyde, glyoxal and acrolein.
d) At temperatures above 700°C, these unsaturated products react together and through free radical reaction, form a highly reactive carbonic residue [Tillman, D.A. and Pitt, N.1977].

Figure 1 below indicates the results for DTA and TGA spectra for the rice husk under different burning temperatures. Differential thermal analysis (DTA), and thermogravimetric analysis (TGA), showed the first peak at 95°C was caused by dehydration. Between 150°C and 250°C, a low intensity endothermic reaction was followed by one extreme at about 300°C which may have been due to oxidation reactions. The amount of char formed was about 60% of the initial weight

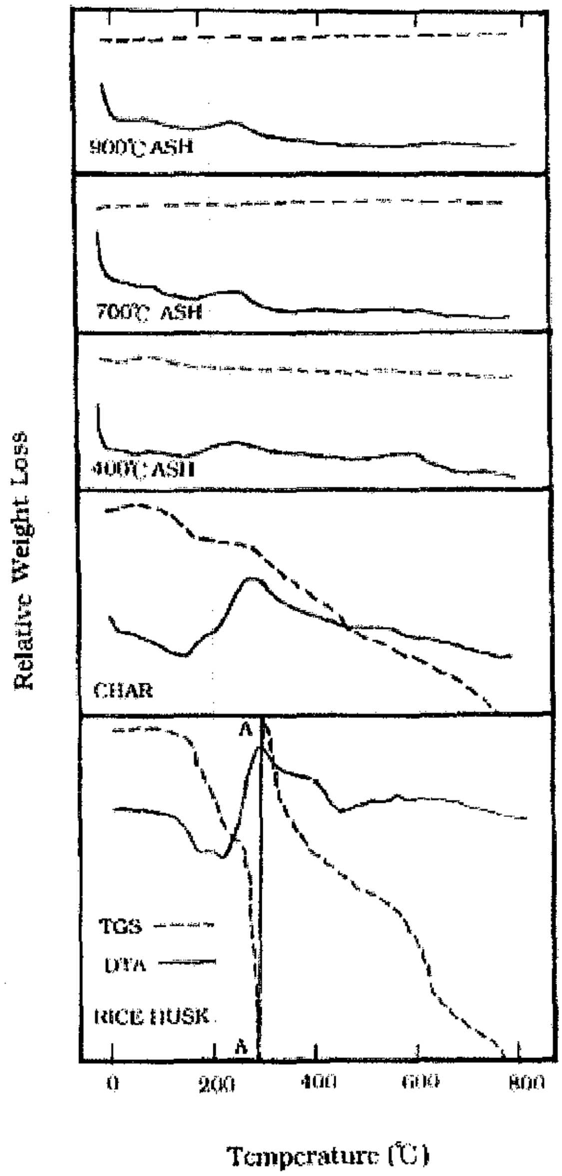


Figure 1 The DTA and TGA spectra for the rice husk under different burning temperatures

X-ray, chemical, and EDAX analyses revealed that the higher the burning temperature, the greater the Si content in the ash. The K, S, Ca, Mg as well as several other compounds were revealed to be volatile, as shown in Figure 2 below:

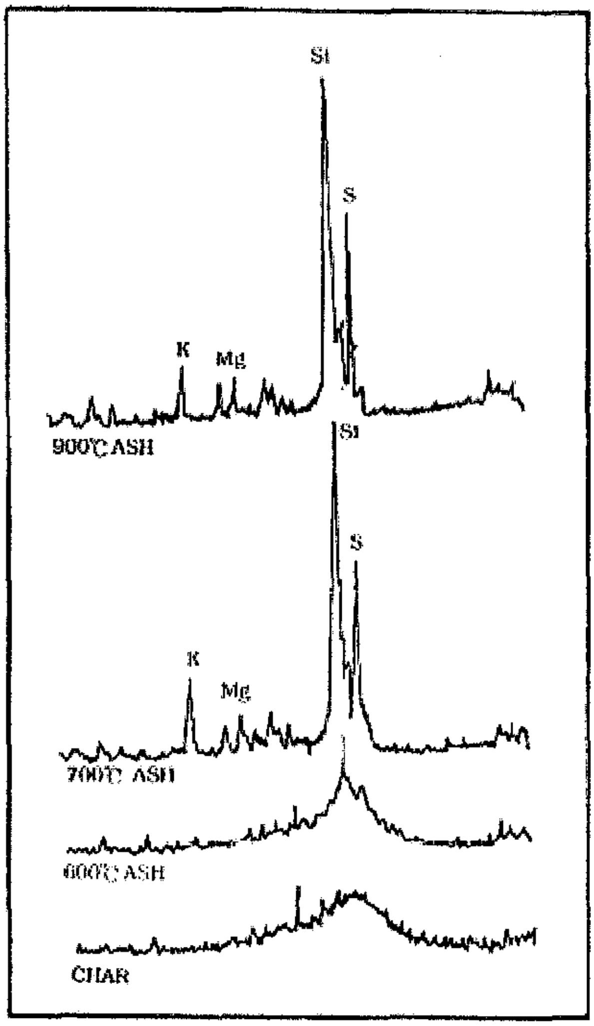


Figure 2 The x-ray diffraction pattern of RHA under different burning conditions

Table 3 shows the pore analysis of RHA under different burning temperature. The diameter of pores of RHA between 600°C and 700°C is the highest and therefore, the pozzolanic reaction of ash formed at this temperature should also be greatest. The lower the burning temperature, the lower the energy consumption and thus, temperatures of 600°C to 700°C for rice husk ash formation do not involve excessive energy [Hwang,C.L.1989].

Table 3 Pore analysis of RHA under different burning temperatures

Burning Temperature (°C)	Mercury Penetration Volume (cm^3/gm)	Mean Pore (Å)	Median Pore (Å)
Char	0.3657	5257	4585
400	0.3379	5954	6847
600	0.2912	6069	6847
700	0.0795	5867	5718
800	0.0643	5446	5250
900	0.0393	5150	4483
1000	0.0323	4972	3867

2.2.2 The Effect of Burning Time & Furnace Environment

Above 800°C, an increase in the burning temperature, time, and environment tend to cause a sintering effect (coalescing of fine particles), and is indicated by a dramatic reduction in the specific surface (Table 4) [Ankra, K.1975]. Combustion environment also plays an important role. It should be noted that a change in the rate of oxidation from moderately oxidizing conditions (CO_2 environment) to highly oxidizing conditions (oxygen environment) was responsible for the steep drop in the micro porosity (Table 3) and surface area (Table 4).

Table 4 Effect of burning conditions on the crystal structure and surface area of RHA

Burning Temperature	Hold Time	Environment	Properties of Ash	
			Crystalline	Surface Area, m^2/g
500~600	1 min	moderately oxidizing	non-crystalline	122
	30 min			97
	2 hrs			76
700~800°C	15 min~1 hr			100
	>1 hr	highly oxidizing	partially crystalline	6-10
>800°C	>1 hr		crystalline	<5

Table 4 shows that optimum incineration condition is important to obtain reactive rice husk ash with micro porous and cellular structure. But, it is not suggested to burn rice husk above 800°C longer than one hour because it will produce low surface area and has crystalline properties. Also, it is believed that rapid cooling may increase the reactivity of RHA.

2.3 Analysis of the Quality of RHA

The quality of RHA actually depends on the method of ash incineration and the degree of grinding. Different combustion process used will produce different quality of RHA. It also depends upon the preservation of cellular structure and the extent of amorphous material within the structure. Higher quality of RHA has high amorphous within the structure.

2.3.1 Different Sources

The production of rice husk in the whole world is about 100 million metric tons a majority of it coming from countries in Southeast Asia. Depending on growing conditions and the variety of rice species, the quantity of straw also varies, but the chemical composition of different sources is similar. Typical components of RHA, as shown in Table 1 are [Housten, D.F. 1972]:

Cellulose	40-50%
Lignin	25-30%
Ash	15-20%
Moisture	8-15%

After burning at a suitable temperature and time (about 600-700°C, 2 hours), in an industrial furnace, the rice husk is composed of 90-95% SiO_2, 1-3% K_2O and < 5% unburnt carbon. The quality of ash from different sources after proper burning varies only slightly. For use, the RHA should be amorphous and highly porous. The pozzolanic reactivity is also dependent on the surface area of RHA. Rice husk ash with a surface area of 50-100 m^2/gm is now available. The pozzolanic activities for the RHA when mixed with < 70% (by weight) cement is greater than 100%.

2.3.2 Different Processes

Burning process affects the quality of rice husk ash produced. Research studies have shown the influence of processing on a variety of properties of the RHA.

a. Open-Field Burning

Open-field burning of rice husk not only produces poor quality of ash, but is banned in many countries due to pollution problems. Uncontrolled burning results in a structure of highly crystalline form that is of low reactivity, because of its low surface area.

b. Fluidized-Bed Furnace Burning

Fluidized-bed furnace is designed to control burning of rice husk. In the process, the heat from the combustion of rice husk was utilized to produce steam or electricity. A close control of the time-temperature parameter in the burning operation is maintained. A highly pozzolanic ash is produced. Highly pozzolanic RHA is created by maintaining husk combustion temperatures between 500 and 700°C for a relatively long period to remove most of the carbon [Mehta,P.K.1992], or at temperatures around 700-800°C for less than one minute. The chemical analysis of the ash samples produced by a fluidized-bed furnace showed 80-95% SiO_2, 1-2% K_2O, and 3-18% unburned carbon. The ash was highly cellular, with 50-60 m^2/g surface area measured by nitrogen adsorption.

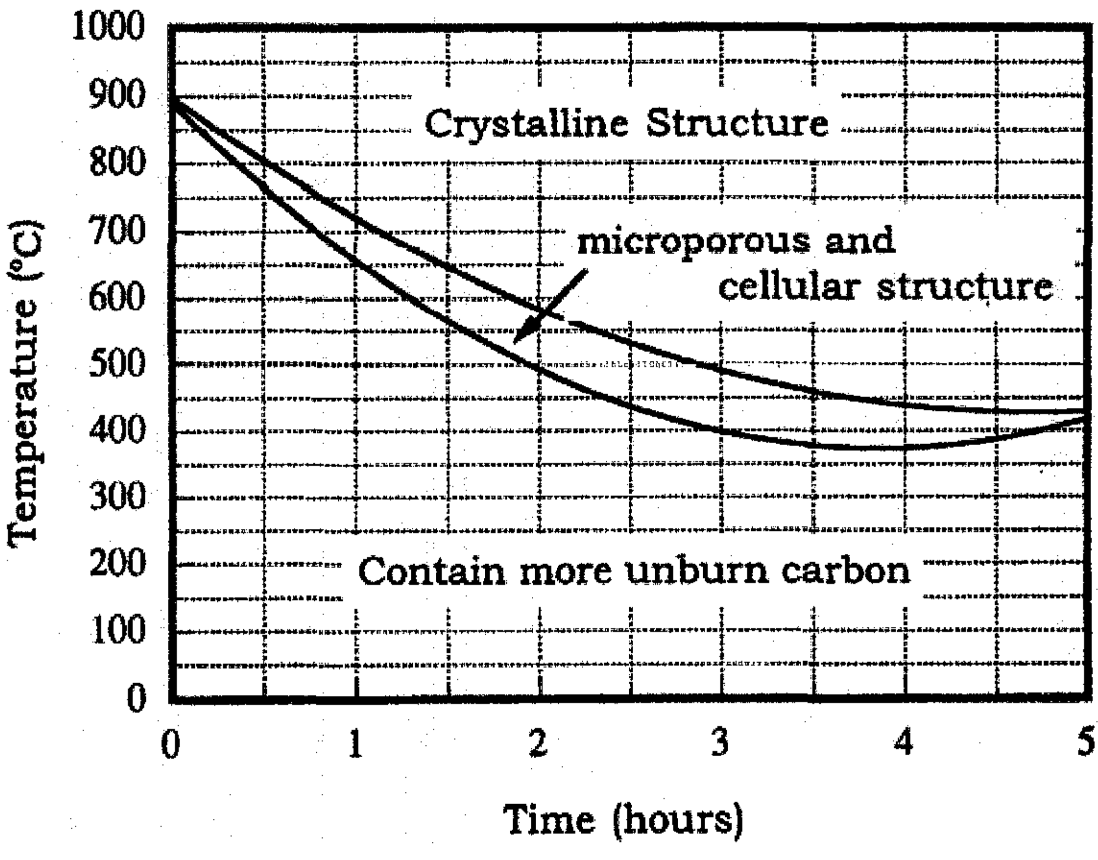
c. Industrial Furnace

A modern industrial furnace has been recently used due to environmental and economic reasons [Mehta, P.K.1992]. Depending upon the efficiency of combustion, the silica content of RHA may be in the range of 90-95% with residual carbon as the main remaining ingredient. In addition to residual carbon, alkalis ranging from 1 to 3% form the other impurity. By controlled combustion in the industrial furnace, it is simple to produce RHA with silica in an amorphous and highly cellular form, with 50-100 m^2/g surface area. This type of rice husk ash is highly pozzolanic.

2.3.3 The Effect of Burning Time and Temperature on the Surface Area and Its Reactivity

The RHA must be burned for the correct time and temperature to achieve the requisite pozzolanic activity. Table 4 before clearly indicates that not only the burning temperature [Ankra,K.1975], the burning time is equally important in removing carbon while keeping the silica in an amorphous and highly cellular form. The surface area of RHA burned at 500-600°C for 1 minute is as high as 122 m^2/g without causing crystallization, as shown in Table 4. Longer burning times will cause collapse of the cellular form and also coalescence of the fine pores [Hwang,C.L.1989], which consequently causes a reduction in surface area [Mehta,P.K.1992]. At higher temperatures with longer burning times, a crystalline structure is formed with a sharp reduction in surface area. This lowers the pozzolanic activity. Figure 3 below indicates the ideal time/temperature path to obtain optimum quality rice husk ash with a micro porous and cellular structure which is highly reactive.

Figure 3 The optimum incineration condition curve for obtaining reactive cellular RHA



2.4 Early Characteristics Of Concrete With RHA

The early characteristics of concrete with RHA depend on the water to cement ratio, the amount of paste used, the amount of RHA added, other admixtures used and mixture proportion.

2.4.1 The Workability of Fresh Concrete with RHA

At a given water to cement ratio, small addition (less than 2 to 3 by weight of cement) of RHA may be helpful for improving the stability and workability of concrete by reducing the tendency towards bleeding and segregation [Mehta,P.K.1983]. This is mainly due to the large surface area of rice husk ash which is in the range of 50 to 60m^2/g .Large additions would produce dry or unworkable mixtures unless water-reducing admixtures or superplastizers are used [Hwang, C.L.1989]. Due to the adsorptive character of cellular rice husk ash particles, concrete containing RHA require more water for a given consistency. At high water-cement ratio, the workability tends to improve [Hwang, C.L.1989]. The addition of sand will significantly reduce the flow table spread.

For a given consistency, the reduction of water requirement can lead to an overall improvement in many engineering properties. Granulometric characteristics of the coarse aggregate, fine aggregate, and cement particles influence the volume of voids and water requirement of a concrete mixture. The addition of fine particles of a mineral admixture, typically in the order of 1 to 20 μm in size, would supplement the cement grains in further reducing the volume of voids in the concrete mixture. Consequently, it will require less water to produce a concrete of a given consistency [Hwang, C.L.1989].

The workability of fresh concrete with RHA can be improved by densifying the mixture [Hwang C. L. and Johansen V.1989]. The process uses cement and rice husk ash with water to fill the pores and voids within well-compacted aggregates. The density of concrete made by this process is higher than that of conventional mixtures with more cement. Slump can be controlled to 250 + 20 mm range with excellent rheological properties and with small reduction in slump after 45 minutes.

2.4.2 The Setting Time of Concrete with RHA

Unlike other pozzolanic materials, rice husk ash tends to shorten the setting time. This may be due to the water adsorption ability of the cellular form of rice husk ash and hence, the surrounding water-to-cement ratio is reduced. It is further substantiated by the early detection of the ultrasonic pulse velocity, as shown in, reflects that the rigid silica cellular skeleton also plays an important role in setting time. Higher water-to-cement ratio tends to increase the setting time because there is less contact between the open matrix and the silica cellular structure causes a reduction in early strength development.

2.4.4 The Modules of Elasticity, Creep and Shrinkage of Concrete with RHA

Modulus of elasticity, creep and drying shrinkage characteristics of concrete are greatly influenced by strength of concrete and stiffness of aggregate. Since ultimate strength of concrete containing pozzolans will result in significant gain in the modulus of elastic and creep will be low after 28 days [Mehta, P.K.1986]. Since the addition of rice husk ash reduces bleeding, the constructor needs to carefully protect the concrete surface when conditions for plastic shrinkage cracking prevail [Mehta, P.K.1986]. The pozzolanic reaction of rice husk ash refines the pore structure; hence at the same water-to-binder ratio the amount of drying shrinkage of concrete with the addition of rice husk ash is slightly higher than that of concrete without rice husk ash [Hwang, C.L.1989].

2.4.3 The Compressive Strength and Impermeability of Concrete with RHA

In normal concrete, the transition zone is generally less dense than the bulk paste and contains a large amount of plate-like crystals of calcium hydroxide, with the c-axis perpendicular to the aggregate surface [Mehta, P.K.1993]. This is suspected to induce micro cracks due to the tensile stresses induced by thermal and humidity change. The structure of the transition zone is the weakest phase in concrete and has a strong influence on the properties of the concretes.

The addition of pozzolanic materials can affect both strength and permeability by strengthening the aggregate-cement paste interface and by blocking the large voids in the hydrated cement paste through pozzolanic reaction. 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-structure which thus becomes densified. The porosity of cement paste is reduced, and subsequently, the pores are refined. Mehta [Mehta, P.K.1992] has shown significant reduction in the porosity of cement paste with RI-IA additions and refinement in the pore structure. Pozzolanic reaction is a slow process and proceeds with time. The pore refinement is still in progress even after 28 days.

Rice husk ash adsorbs large amount of water due to its high specific surface area. This reduces bleeding water. The high absorption of the RHA has been shown by Hwang [Hwang, C.L.1989] (Figure 4). It improves the weakest zone under the aggregate. However, adding the correct amount of rice husk ash is important for achieving high strength. Large amounts of rice husk ash have an adverse effect and reduce strength. The early strength of concrete is a function of water-to-binder ratio. As long as the water to-binder ratio is kept constant, the early strength of concrete will be similar, but the ultimate strength will be enhanced due to pozzolanic reactions.

It is further seen that above 54 kg/m^3 rice husk ash addition, there is no influence on the strength. However, it decreases the permeability of concrete. At a high water to cement ratio, the addition of RHA to cement paste will not only reveal a significant effect on strength at early ages, but the strength at later ages also tend to be higher than those with lower water to cement ratios. A higher water to cement ratio also contributes to a lower heat of hydration.

The pore refining effect of rice husk ash has shown a surprising result in permeability of concrete. Each percent of rice husk ash can improve at least 0.6 times of permeability at 1 year. No admixtures or processing techniques in concrete technology are known to yield a concrete product with such low chloride permeability so far. The potential usefulness of rice husk ash, as a cement or concrete additive, for applications where the corrosion of reinforcing steel is a major concern is obvious. Hence, the use of rice husk ash is quite significant for those areas that need water resistance, and good durability like in the marine environment.

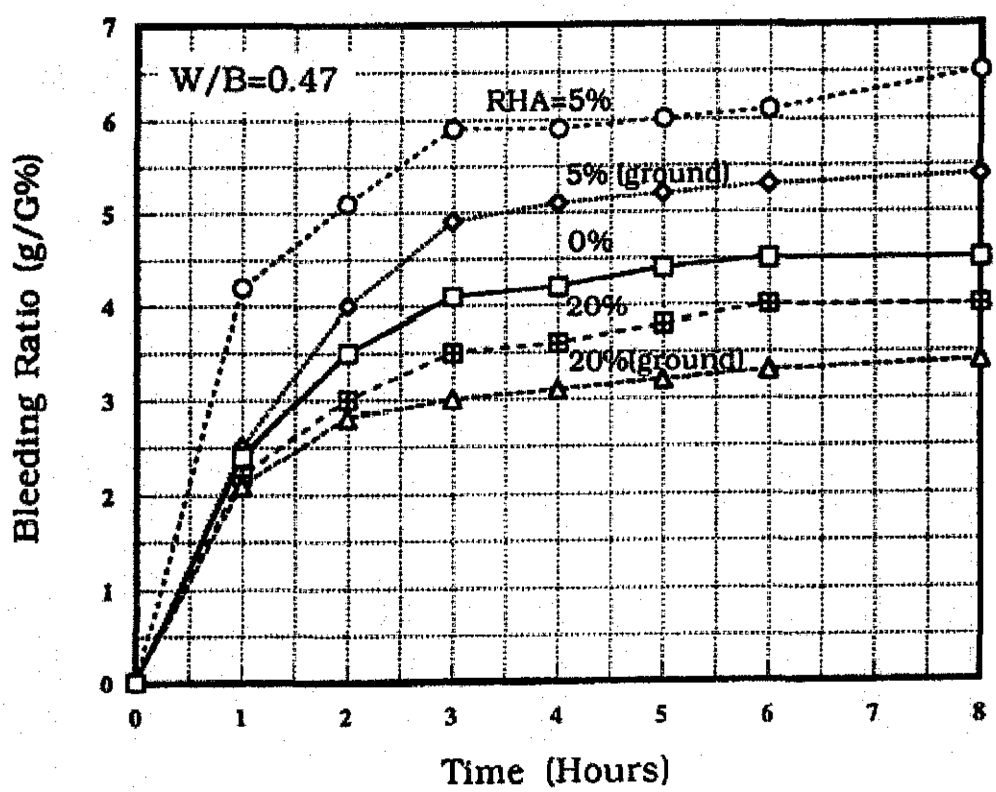


Figure 4 The bleeding ratio of cement paste with RHA

2.5 The Workability Tests

2.5.1 The Slump Test

The workability of concrete can be measured on-site by the 'Slump Test'. This test involves taking a sample of the mix and filling a cone with four equal layers of concrete. Each layer is compacted with 25 strokes of the rod, each stroke penetrating the layer below. This will ensure that even compaction of the material is achieved. When the cone is lifted off the material should 'slump' to provide a measurement of the difference between the height of the cone and the slumped concrete. The greater the slump is, the more workable the concrete.

If the concrete collapses totally this shows that the mix is too wet and too fluid to compact, it will cause segregation of the materials with the larger aggregate sinking to the bottom during compaction. If the material collapses on one side only are shows that the material is too dry and will be unworkable. The optimum slump is when the material stays together and just bulges from the centre. This then shows that the material is workable. The grade for different height of slump is shown on Table 5 below.

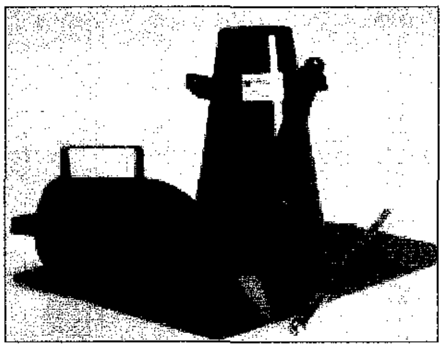


Figure 5 The Slump Cone Funnel

Table 5 The grade for different height of slumps

Consistency grade	Slump (mm)	Recommended method of compaction
Stiff, K1	0 - 60	Mechanical compaction like vibration
Plastic, K2	60 – 130	Mechanical or hand compaction (rodding, tampering)
Flowing, K3	130 – 200	Hand compaction or no compaction
Self compacting, K4	≥ 200	No compaction

2.5.2 The VeBe Test

The Vebe time test is a more scientific test for workability than the Slump Test, in that it measures the work needed to compact the concrete. The freshly mixed concrete is packed into a similar cone to that used for the slump test. The cone stands within a special container on a platform, which is vibrated at a standard rate, after the cone has been lifted off the concrete. The time taken for the concrete to be compacted is measured. Vebe times range from 1 second for runny concrete to more than 12 seconds for stiff concrete. Unlike the slump test, the Vebe time test gives useful results for stiff concretes.

The levels of workability defined in the DOE Method give both slump values and Vebe times for each level, and these values are used in first mix for converting between Slump values and Vebe times. The DOE Method defines four levels of workability, which are given in the table 7 below:

Table 6 Levels of workability

Description	Slump Range		Vebe Time Range
	mm	In.	Seconds
Very low	0 to 10	0 to	>12
Low	10 to 30	to 1	12 to 6
Normal	30 to 60	1 to 2	6 to 3
High	60 to 180	2 to 7	3 to 0

2.5.3 The Compacting Factor Test

This test also measures the workability of concrete in a more precise way than the slump test. It measures the weight of uncompacted concrete and compared it with the weight of partially compacted concrete, sometimes known as the 'drop test'.

Compacting Factor Apparatus, complying with BS1881: Part 103, the equipment is appropriate for concrete mixes of low, medium and high workability. Consist of two conical hoppers fitted with tightly hinged trap doors which help facilitate the falling of concrete into the cylindrical mould. The frame which the hoppers and mould are mounted upon is manufactured from rigid steel.

The top cone is filed with well mixed loose concrete and weighed. It is then allowed to drop to the lower cone and then to the bottom cylinder. The bottom cylinder is smoothed off level and any surplus concrete on the outside wiped away. The cylinder is then weighed.

The difference between the weight of the concrete placed in the top cone and that of the cylinder provides a measure of workability. The higher the weight of the cylinder to the cone the more workable the concrete, but the difference should not be more than 1.

Figure 6 Compacting Factor Tests

2.5.4 The Concrete Impact Test (Rebound Hammer Test)

Concrete Impact Test, Rebound Hammer model HT-225A. When testing the strength of concrete, the concrete test impact test hammer uses a certain elastic force to transit the impact force of an impact Rebound hammer to the surface of concrete, its initial kinetic energy redistributes, a part of energy in the form of plastic deformation or residual deformation is adsorbed by the concrete, and another part of energy which is proportional to the surface hardness is transmitted to the impact hammer, making the impact test hammer resize to a certain height, then the strength of the concrete is derived from the proportional relation between the height of resilience and the concrete strength.

With the merits of simple structure, easy correction, maintenance & repair, and portability, the concrete impact test Rebound hammer is widely used in the civil engineering and construction industry for testing the strength of concrete. Compared to other nondestructive tests, the concrete impact test hammer is an economical and practical nondestructive testing instrument. HT-225A is used for testing the strength of various concrete materials, slabs, beams, columns, trusses, bridges etc.

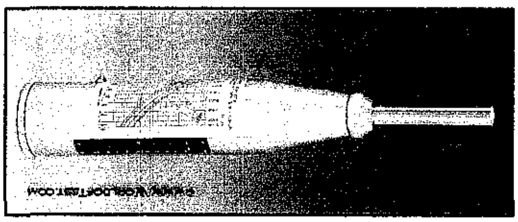


Figure 7 Rebound Hammer

2.5.5 The Ultrasonic Pulse Velocity Test (UPV Test)

Ultrasonic Pulse Velocity tests are performed to assess the conditions of structural members with two-sided access such as beams, columns, walls, and elevated slabs. Voids, honeycomb, cracks, delaminations and other damage in concrete, wood, stone and masonry materials can be located with this method. UPV tests are also performed to predict strength of early age concrete and as a relative indication of concrete quality.

The instrument to conduct UPV test consists of a recorder with two transducers. Transducers with 200 kHz frequency were attached to the concrete specimen using white grease as a couplant. Reading of the transition time was performed to tenths of a microsecond in longitudinal direction of specimen. The UPV was calculated by simply dividing the specimen length by the transition time.

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, fire, etc.

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. For example, using the standard 50 mm diameter transducers supplied with one popular UPV system, placed 300 mm apart, the potential error in the assumed path length +/- 50 mm, or +/-17%. Placing the same transducers 1000 mm apart will still give rise to a potential variation of +/- 50 mm, but in this case the error range will be reduced to +/-5%.

Table 7 Quality of Concrete and Pulse Velocity

General Conditions	Pulse Velocity, ft/sec
Excellent	Above 15,000
Good	12,000 – 15,000
Questionable	10,000 – 15,000
Poor	7,000 – 10,000
Very Poor	Below 7,000

2.5.6 Superplasticizer- Sikament-NI

Sikament-NI is a dual action liquid super plasticizer for the production of free flowing concrete or as substantial water reducing agent for promoting high early and ultimate strength. Sikament-NI is chloride free and is compatible with all types of Portland Cement.

2.5.7 The Compressive Strength Test

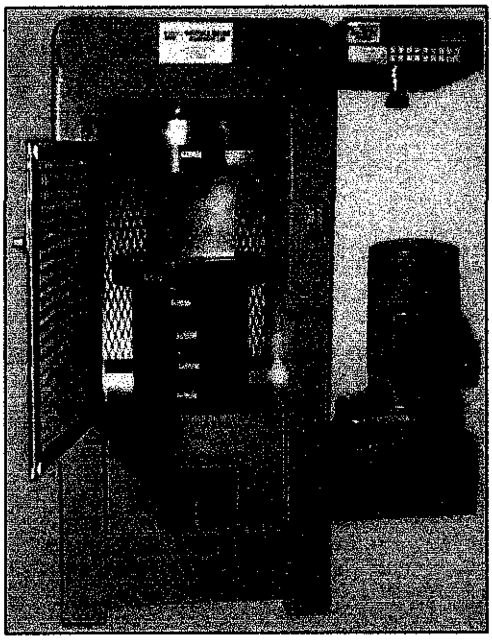


Figure 8 Compressive Strength Machine

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.

Axial compression testing is a useful procedure for measuring the plastic flow behavior and ductile fracture limits of a material. Measuring the plastic flow behavior requires frictionless (homogenous compression) test conditions, while measuring ductile fracture limits takes advantage of the barrel formation and controlled stress and strain conditions at the equator of the barreled surface when compression is carried out with friction.

Axial compression testing is also useful for measurement of elastic and compressive fracture properties of brittle materials or low-ductility materials. In any case, the use of specimens having large *L/D* ratios should be avoided to prevent buckling and shearing modes of deformation.

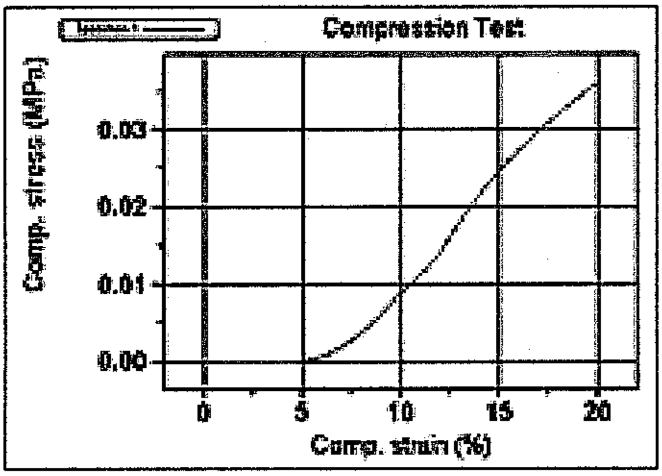


Figure 9 Stress-Strain Diagrams

The following materials are typically subjected to a compression test.

- Concrete
- Metals
- Plastics
- Ceramics
- Composites
- Corrugated Cardboard

2.5.8 The XRD Test

X-ray powder diffraction is one of the most sensitive methods for the analysis of crystalline forms of silica. In addition to detection and quantification, it can determine the specific crystalline species in the sample.

Compared with the alternative techniques for analyzing crystalline silica in bulk and respirable samples, XRD is unique in its sensitivity to the specific crystalline phase or phases that may be present in the sample. For identification applications to detect quartz and cristobalite and to determine the interfering minerals, diffraction techniques are fast and easy to apply. For quantification applications, diffraction methods have proved as accurate as any of the other methods available [International Symposium, Cambridge, 1992].

2.5.9 The correlations between compacting factor, Vebe time and slump

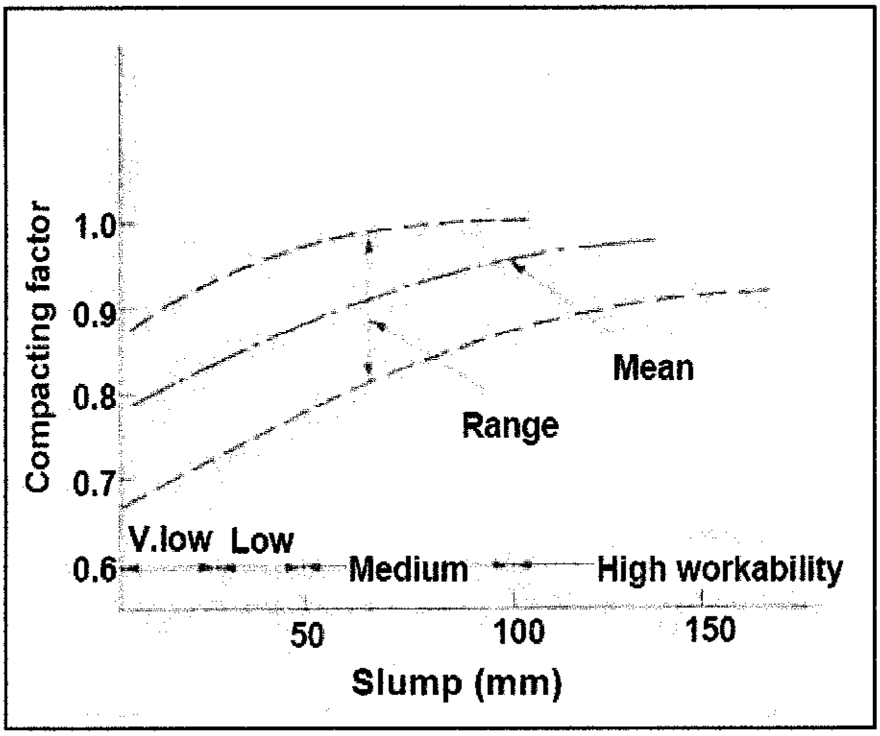


Figure 10 Correlation between slump and compacting factor

Based on the Figure 10 and Figure 11, some degree of correlation between the results exist, however the correlation is quite broad since each tests measures the response to different conditions.

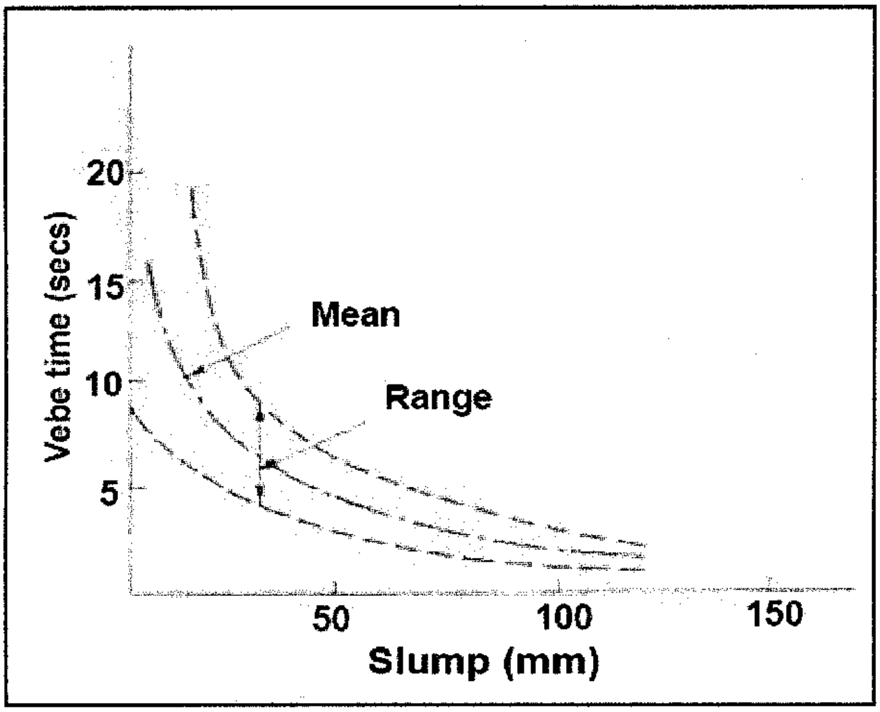


Figure 11Correlation between slump and Vebe test

CHAPTER 3
METHODOLOGY

3.1 Project Implementation

The project implementation will be undergone for about one year. Below are currently defined methodologies for this stage of the research project and also some lab tests. The techniques listed below are the techniques that were applied into the project.

3.1.1 Research and Literature Review

Literature review, a common method in any research had been crucially important in pursuing few aspects in the study, which are the history and background of the problem, the related studies been done before, and the current issue takes in place in the gas industry. In order to collect information regarding these, primary and secondary sources are collected from library, websites and information or data from experienced engineers or technical staffs. The gathered information are later digested and converted into summarization for analysis purposes.

3.1.2 Combustion Process to Produce RHA

Several lab sessions have been done in order to produce the RHA. The Microwave Incinerator is used to do the combustion process of the rice husk. The lab temperature for the incinerator was set up at 4 different temperatures and constant time.

Table 8 Temperatures and times for burning incinerator

No.	Temperature, °C	Time,min
T1	280	10
T2	360	17
T3	520	10
T4	550	6

**Note:The incinerator is set up to flow some air at T2/360°C for 17 minutes.*

Since the RHA that produced from those temperatures are blackish show that the RHA produced is not completely burnt-there is still carbon in it. Other ways of burning is tried in order to produce a grayish RHA.

a. The RHA is burnt twice. The first time is at 150°C and is let to cold down. The next day the RHA is burnt for 500°C before is let to cold down.
b. The RHA is burnt twice. The first time is at 150°C and is let to cold down. The next day the RHA is burnt for 550°C before is let to cold down.

The temperature is increased for the second burning from 500°C to 550°C in order to increase the grayish RHA produced and reduced the carbon in the RHA. The carbon is less produced as long as the RHA is burnt between 500°C and 600°C. The burnt RHA is grinded using LA Abrasion Machine and then sieved. The allowance size of the RHA is below 212 μm.

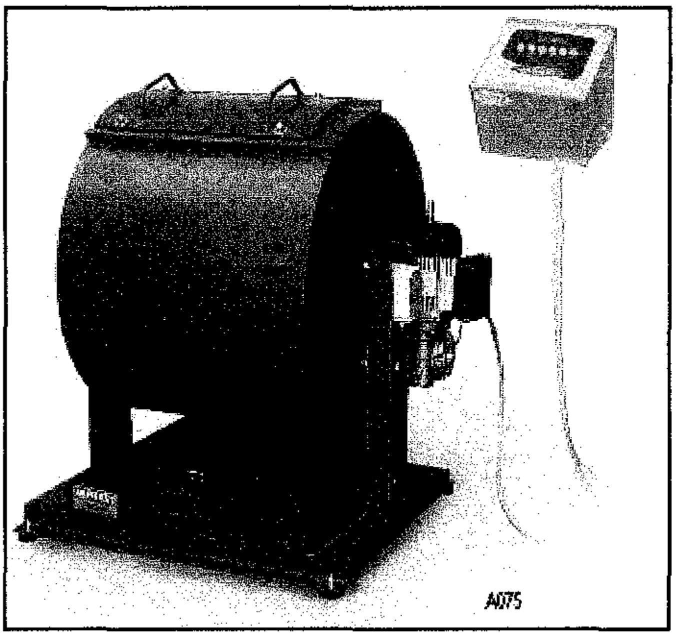


Figure 12 LA Abrasion machine

Below is some information about the microwave incinerator operation:

a. Microwave Incinerator Operation

The charge is loaded into the furnace by the external loading equipment to a predetermined position in the quenching chamber. The quenching chamber is vacuum locked in the loading cycle. After closing the external door and pumping down the pressure within the quenching chamber, the inner thermal door opens. This operation is followed by transference of the charge into the heating chamber. Once the charge is positioned in hot zone and after purging, the heating cycle starts. This cycle is undertaken in vacuum, or in the case of a densely packed charge in convection / vacuum heating.

The carburizing cycle is carried out automatically, according to a programmed recipe with the carburizing gas dosing being carried out via programmable mass flow control valves. SECO/WARWICK provides a FineCarb software program that controls all typical carburizing processes by the use of recipes. This carburizing program is used for typical materials, case depth for typical process temperature ranges. After the programmable carburizing/diffusion time cycle, there is the option of undertaking direct quenching or cooling down for single-time quenching with programmable cooling in vacuum or for accelerated quenching in inert gas.

Durable graphite insulation and the heating elements provide long-lasting and reliable operation of the furnace. The process of quenching in neutral gases takes place in a COLDCAM□ type chamber. This specially designed chamber allows high values of heat transfer exchange coefficient α to be achieved, which depends on the cooling gas flowing at a linear rate around the charge as well as both the type of quenching gas used and its pressure. The cooling system of quenching chamber COLDCAM□ consists of a gas blowers, heat exchanger, guide vanes and gas distributors. The blower's power, vessel construction, and the heat exchanger structure are designed to enable cooling the workload at a pressure of 20 bars absolute. A linear gas flow pattern in the quench chamber allows for hardening of details made of tool steels with large cross sections and height.

This system ensures high hardness uniformity along the length of vertically positioned pieces. The heat treatment cycles of critical steel, for example bearing steel 52100, for cold work steel type O2 (90MnCr5) etc. are achieved. Thus the quenching in this cold chamber COLDCAM□ □ type, with its high cooling gas linear rates gives new opportunities for quenching in comparison with traditional technology which is the foundation of design for single chamber vacuum furnaces.

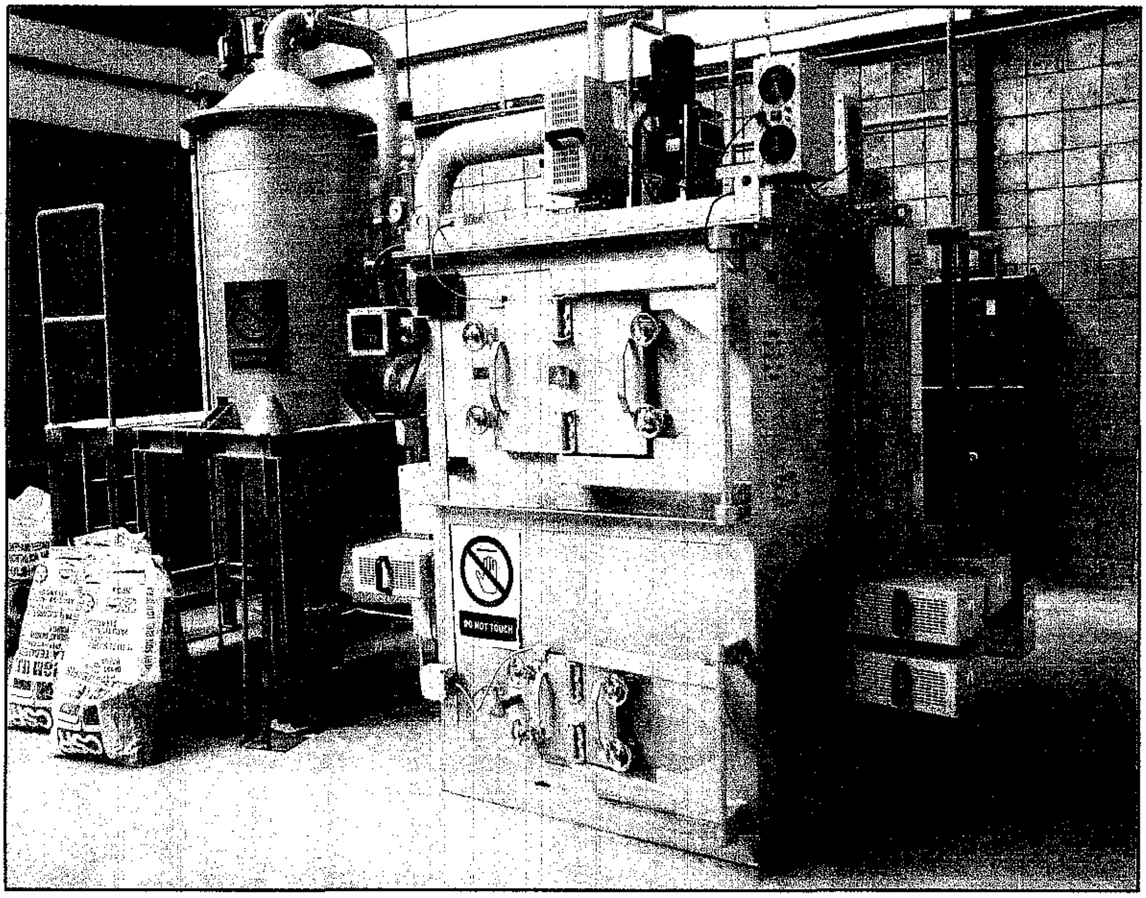


Figure 13 Microwave Incinerator

3.1.3 Experiments to the concrete

The RHA produced is used in the concrete lab. Several mix proportions are adopted and each output of the RHA fresh concrete is compared to the OPC control mix. The RHA concrete is tested to know the compressive strength, splitting tensile strength, hardness and also elasticity modulus. The tests are carried through with ages of 3, 7 and 28 days, with curing in humid chamber. Below are the proportions that are used for mixing the RHA concrete.

Table 9 Proportion for concrete mix

<table>
<tr><th>Mix Code</th><th>w/c ratio</th><th>RHA (%)</th><th>Cement (kg)</th><th>Water (kg)</th><th>Fine Agg. (kg)</th><th>Coarse Agg. (kg)</th></tr>
<tr><td>A0</td><td rowspan="4">0.35</td><td>0</td><td>29.31</td><td rowspan="4">10.26</td><td rowspan="4">30.38</td><td rowspan="4">59.64</td></tr>
<tr><td>A1</td><td>5</td><td>27.85</td></tr>
<tr><td>A2</td><td>10</td><td>26.38</td></tr>
<tr><td>A3</td><td>15</td><td>24.92</td></tr>
<tr><td>B0</td><td rowspan="4">0.4</td><td>0</td><td>25.65</td><td rowspan="4">10.26</td><td rowspan="4">32.79</td><td rowspan="4">60.90</td></tr>
<tr><td>B1</td><td>5</td><td>24.37</td></tr>
<tr><td>B2</td><td>10</td><td>23.09</td></tr>
<tr><td>B3</td><td>15</td><td>21.80</td></tr>
<tr><td>C0</td><td rowspan="4">0.45</td><td>0</td><td>22.80</td><td rowspan="4">10.26</td><td rowspan="4">34.75</td><td rowspan="4">61.79</td></tr>
<tr><td>C1</td><td>5</td><td>21.66</td></tr>
<tr><td>C2</td><td>10</td><td>20.52</td></tr>
<tr><td>C3</td><td>15</td><td>19.38</td></tr>
</table>

a. Prepare the aggregates

The coarse aggregates are washed first to clean the soils before dried under the sun. A clean aggregate is important to make sure that the aggregate will have a good connection with the cements without any disturbance from other particles like soils. The fine aggregates that used for the mixing is also must be dried first. The purpose for cleaning and drying the concrete is to get a maximum result for a dry mix concrete.

b. Procedures for mixing the concretes;

1. Add coarse & fine aggregates.
2. Mix the aggregates for 25 seconds.
3. Add half the amount of the total water needed into the mixture.
4. Mix the mixture for 1 min.
5. Leave the mixture for 8 min.
6. Add all cement & mix for 1 min.
7. Add remaining water & mix for another 1 min.
8. Pour the mixture of concrete into the moulds 150 mm x 150 mm provided.

c. Procedures for Slump Tests

1. Inverted the cone
2. Fill it up with 3 layers of equal volume of concrete
3. Tamped each layer 25 times with rod
4. After that, scraped off the surface
5. The cone than carefully lifted off
6. The slump is measured. The true slump and shear slump are acceptable.

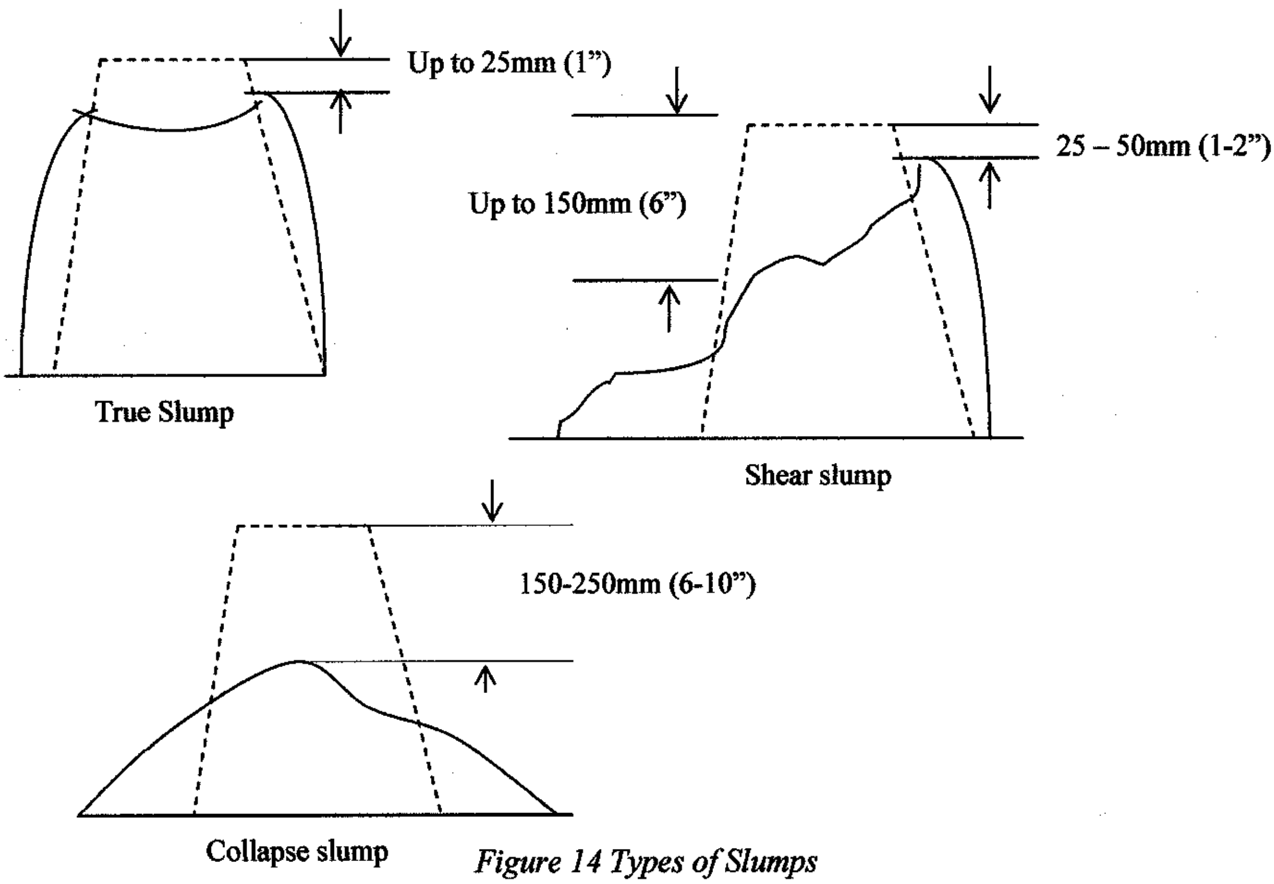


Figure 14 Types of Slumps

d. Procedures for Compacting Test

1. Concrete is placed in an upper
2. Dropped into a lower hopper to bring it to a standard state and then allowed to fall into a standard cylinder.
3. The cylinder and concrete weighed (partially compacted weight)
4. The concrete is fully compacted, extra concrete added and then concrete and cylinder weighed again (fully compacted weight)

$$\text{Compacting factor} = \frac{\text{weight of partially compact concrete}}{\text{weight of fully compact concrete}}$$

* The higher the value of the calculation the more workable the concrete. (A maximum of 1 should be achieved).

e. Procedures for Vebe Test

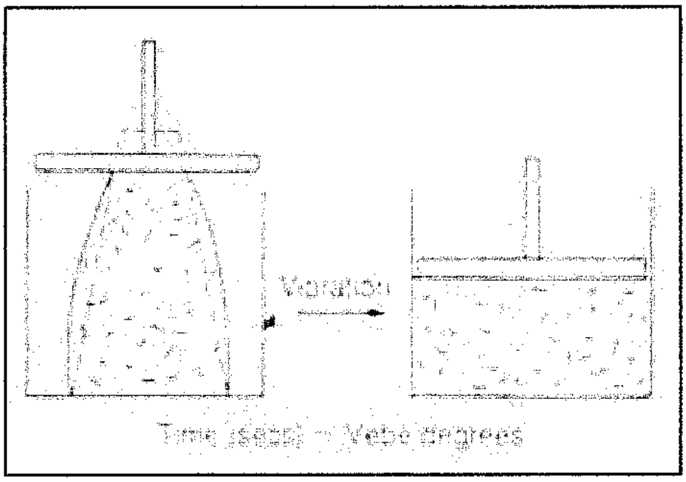


Figure 15 Vebe Test

1. A slump test is performed in a container
2. A clear perspex disc, free to move vertically, is lowered onto the concrete surface.
3. Vibration at a standard rate is applied

f. Procedures for Ultrasonic Pulse Velocity Test (UPV Test)

The ultrasonic pulse velocity (UPV) of a material can be determined by placing a pulse 200 kHz 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. Reading of the transition time was performed to tenths of a microsecond in longitudinal direction of specimen. If the path length is known, then the UPV can be calculated from the path length divided by the transit time.

g. Procedures for Compressive Strength Test

For compressive strength test, the mixture is tested in the specific machine used to conduct the test. The strength is predominantly affected by the amount of pores in the hardened concrete. As this is strongly affected by the non-hydrated water remaining after hardening, the water-cement ratio is taken to be the main determinant of strength.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 The XRD Test

Figure 16 and Figure 17 show two types of RHA produced from different types of combustion process. For Figure 16, the RHA produced was burnt once despite of twice for the new RHA. RHA contain K, Mg, SiO_2 and S. The highest peak in the figures shows the amount of silica dioxide in the RHA. As from the figures, Type B RHA in Figure 17 contains more silica dioxide than the Type A in Figure 16. It has 89 percents of silica dioxide, which is a high amount compared to normal RHA - about 70 to 80 percents of silica dioxide. Therefore it can react more with lime to create the amorphous phase content which will determine the development of strength in the future.

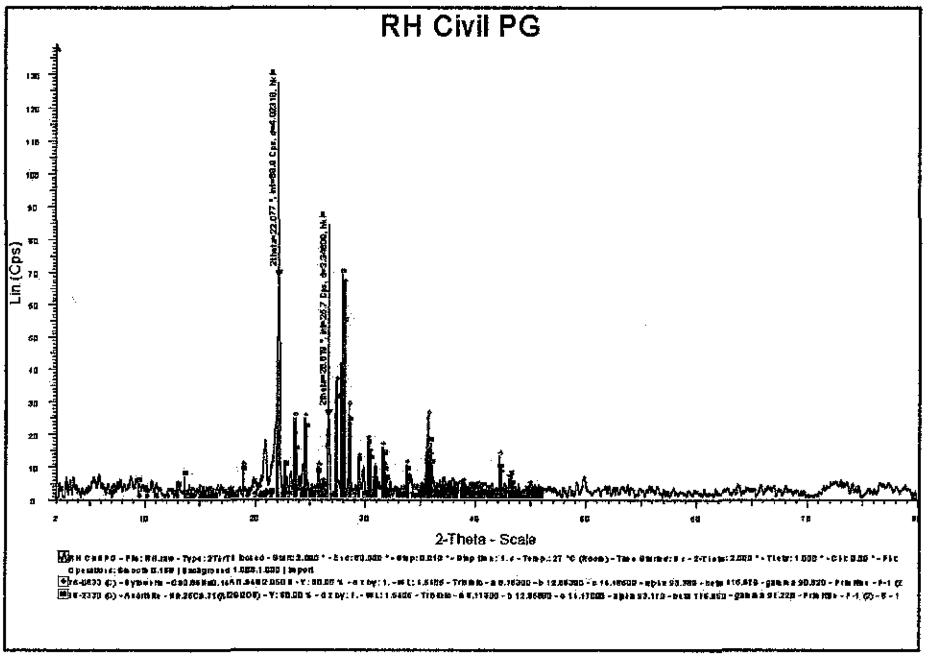


Figure 16 Type A RHA

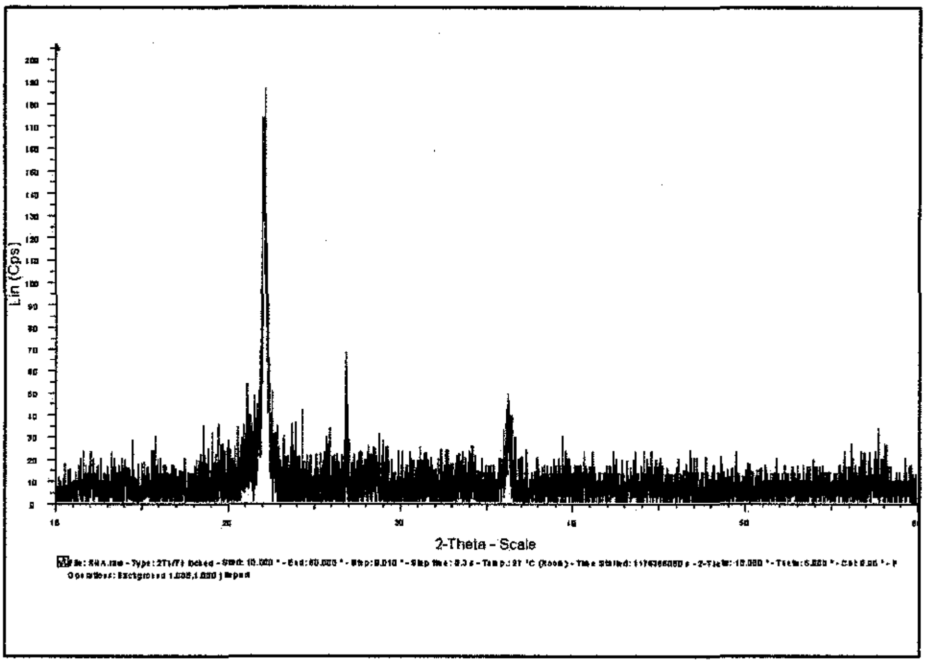


Figure 17 Type B RHA

The Type B RHA in Figure 17 show different pattern from previous researches as it was burn twice-the carbon is lesser and more grayish RHA is produced. The black scatter defines whether the RHA is amorphous or not. The characteristic of amorphous is it has no peak while crystalline is. As from the figure, the scatter is so dense like there is no peak except the high one. Therefore, the RHA is probably contained partially crystalline and partially amorphous, which will explain the RHA has higher strength even for 3 days test.

4.2 The Workability Tests

Table 10 Results for Slump Test, Compacting Factor Test, and VeBe Test

Mix Code	w/c ratio	RHA (%)	Cement (kg/m3)	Slump (mm)	Compacting Factor	Vebe (s)	SP
A0	0.35	0	29.31	45	0.87	8.04	0
A1		5	27.85	41	0.86	8.12	0.2
A2		10	26.38	42	0.83	8.25	0.8
A3		15	24.92	46	0.84	8.19	1.5
B0	0.4	0	25.65	42	0.86	8.11	0
B1		5	24.37	47	0.89	8.01	0.2
B2		10	23.09	43	0.88	8.16	0.9
B3		15	21.80	48	0.87	8.13	1.5
C0	0.45	0	22.80	50	0.92	8.04	0
C1		5	21.66	52	0.94	7.89	0.4
C2		10	20.52	50	0.92	8.02	0.6
C3		15	19.38	54	0.98	7.07	1

The slump of the control concrete and rice husk ash concrete are designed for shear slump which ranged is from 30 mm to 60 mm. This is to make sure that the concrete has a good workability. In order to achieve that range, the superplasticizer-Sikament-NI is used. The amount of Sikament-NI added ranged from 0.1% and 1.5% was totally depended on the properties of the concrete when doing the mixing. The mixture of the concrete must be looked wet so that it is shear slump. Try and error method is used to get that slump.

Based on Table 10 and Figure 18, the dosage of the Sikament-NI required in maintaining the same workability is proportionally increased with RHA content. This is most probably because of the RHA particles which have large surface area, react more with water compared to cement, causing the mixture became dry. Sikament-Ni as a superplasticizer is added to obtain good rheology of the fresh mix.

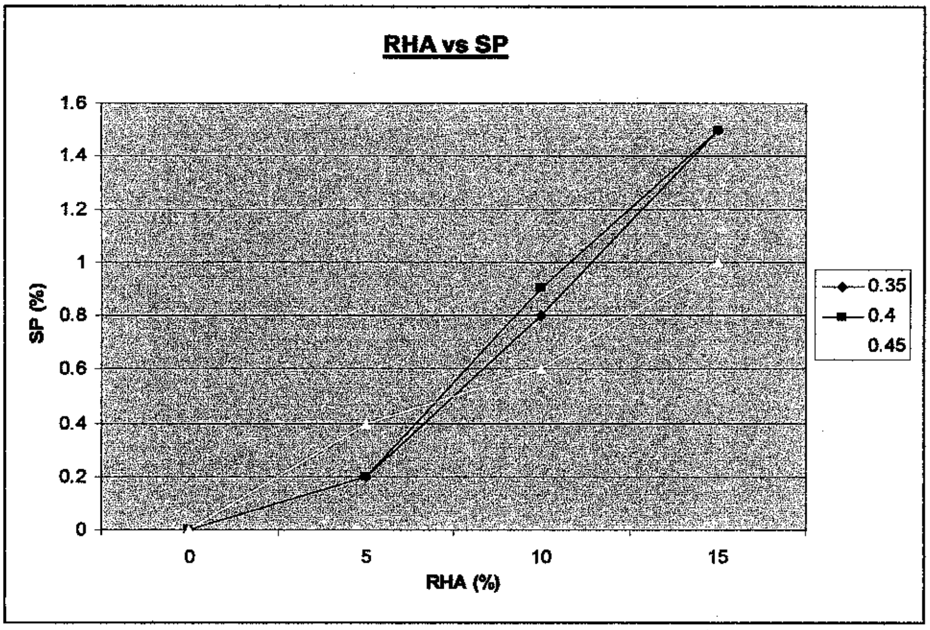


Figure 18 The usage of superplastisizer over RHA

4.3 The Compressive Strength Tests and UPV Tests Results

The compressive strength of the different concretes is shown in Table 11. There were significant differences in the strengths of both the control and the concrete made using RHA (Figure 19, Figure 20, and Figure 21). The RHA concretes developed higher strength compared to the control mix and is expected to increase even after 28 days. This is probably because of the higher fineness in RHA produced larger surface areas for the cement to react with. Hence, more pozzolanic reactivity is produced and strengthens the bonding in the concrete. From the results, adding RHA at 0.4 w/c ratio with 5 to 15 % of the cement will produce higher strength concrete.15% of RHA will increase the compressive strength up to 50% of the control mix strength-60.39 MPa.

Table 11 Results for UPV Tests and Compressive Strength Tests

Mix Code	UPV Tests-transition time(us)			Compressive Strength (N/mm^2)		
	3rd day	7th day	28th day	3rd day	7th day	28th day
A0	34.63	34.87	32.98	40.56	49.41	67.41
A1	36.55	35.85	34.33	28.24	32.63	51.91
A2	36.08	36.07	33.85	31.46	40.09	58.11
A3	36.07	35.18	33.85	31.15	41.43	58.11
B0	36.57	36.55	34.85	28.20	34.31	39.92
B1	35.92	35.58	34.05	30.51	38.15	55.33
B2	35.30	34.77	33.70	38.37	41.98	58.72
B3	34.88	34.30	33.85	35.08	42.18	60.39
C0	37.57	35.65	33.42	17.39	22.29	40.02
C1	35.67	34.55	33.30	28.91	35.09	51.33
C2	36.12	35.23	33.87	25.04	33.63	51.40
C3	38.10	35.53	33.98	24.83	32.67	54.01

For mixture A, it used Type A RHA (Figure 16). Since the RHA has more carbon, using it as cement replacement is not so effective. The developments of strength of the RHA concrete are affected and reduced smaller than the control mix concrete, as in Figure 19.Thus; the Type A RHA is not suitable for use in concrete.

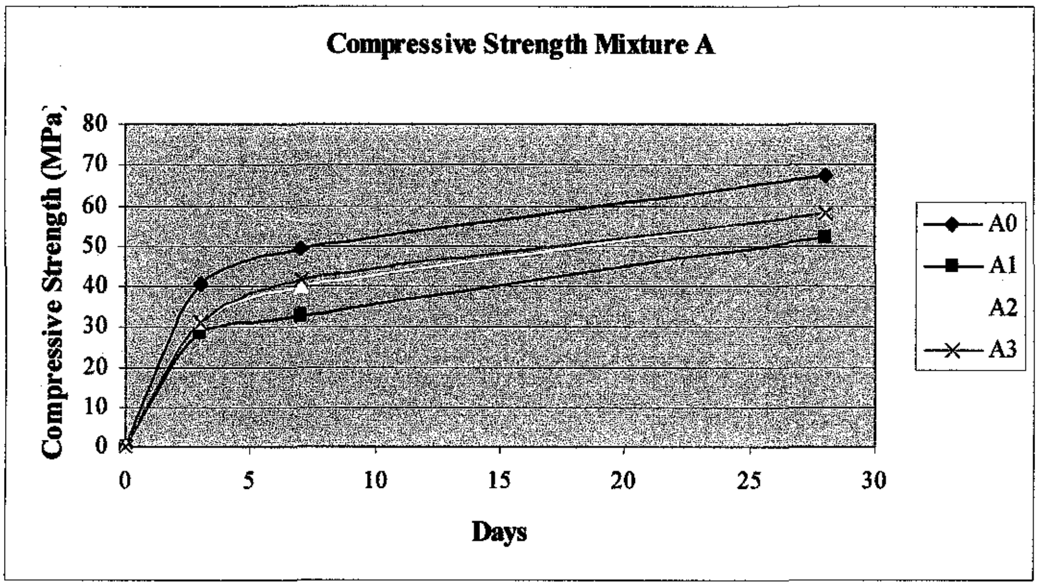


Figure 19 Graphs of compressive strength for 0.35 w/c ratio with 0%, 5%, 10%, and 15% of RHA

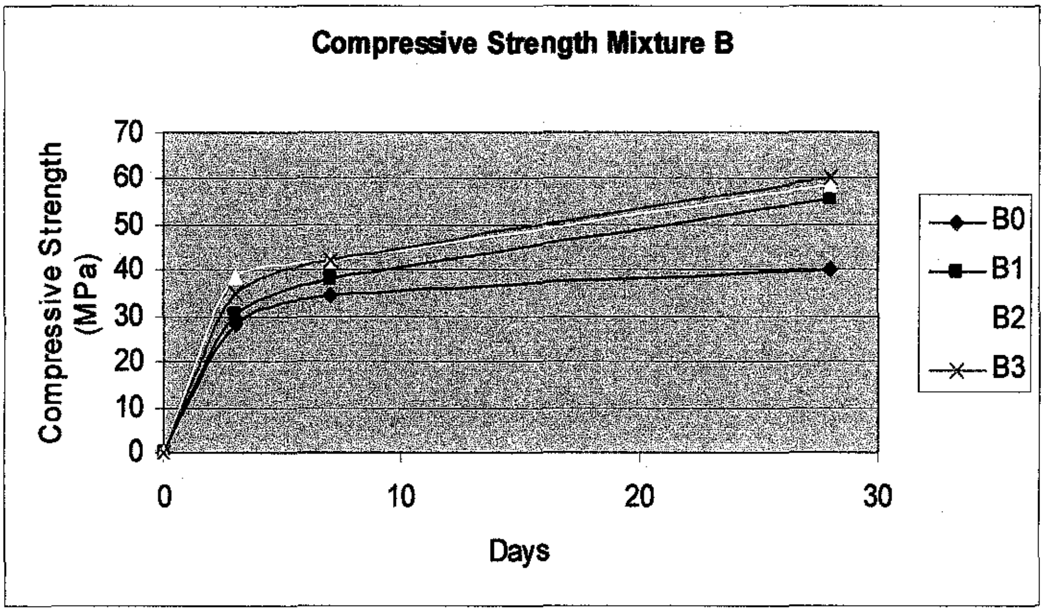


Figure 20 Graphs of compressive strength for 0.40 w/c ratio with 0%, 5%, 10%, and 15% of RHA

The Mixture B (Figure 20) and Mixture C (Figure 21) are using the Type B RHA (Figure 17). This RHA has high silica dioxide and less carbon in it. It significantly develops the strength of the concrete compared to the control mix concrete. Mixture B has higher compressive strength than Mixture C. It develops strength at 60.39 MPa at Day 28, which is 50% of the strength of the control mix concrete; 39.92 MPa. Therefore the optimum inclusion of RHA in concrete achieved is when the RHA is at 0.4 w/c ratio (Mixture B) with 15% of RHA (B3).

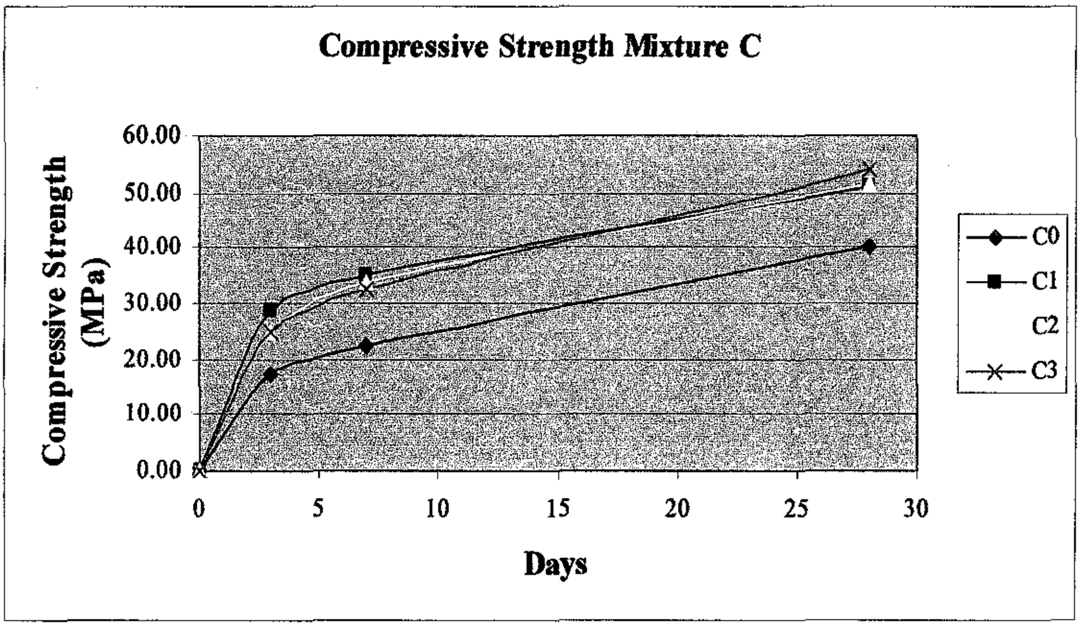


Figure 21 Graphs of compressive strength for 0.45 w/c ratio with 0%, 5%, 10%, and 15% of RHA

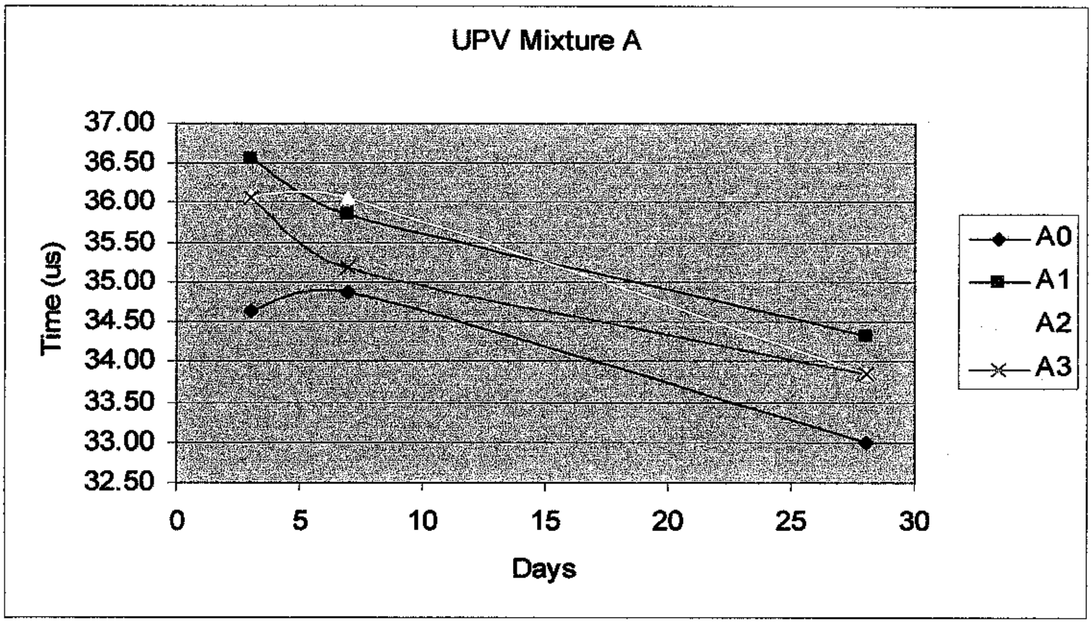


Figure 22 Graphs of UPV test for 0.35 w/c ratio with 0%, 5%, 10%, and 15% of RHA

Since the Mixture A used Type A RHA, the UPV Test will result in decreasing value for 5, 10, and 15 % RHA (Figure 22).The control mix is denser than the RHA concretes. As for Mixture B and Mixture C, the result is expected different because different type of RHA used. Types B RHA is used resulting the RHA concretes in Mixture B and Mixture C are denser than the control mix (Figure 23 and Figure 24).

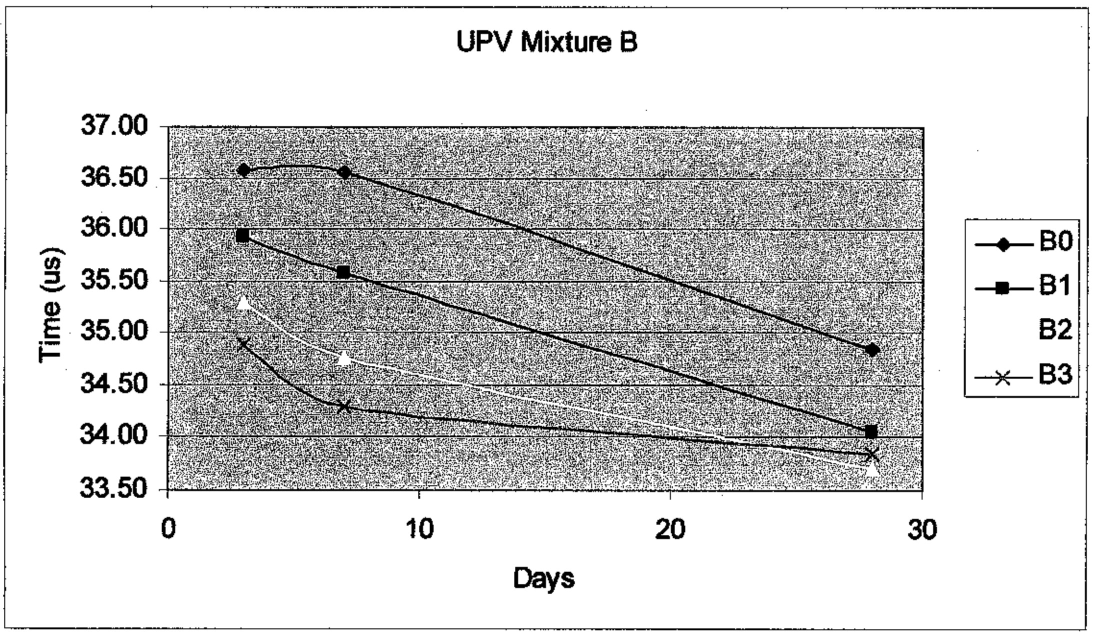


Figure 23 Graphs of UPV test for 0.40 w/c ratio with 0%, 5%, 10%, and 15% of RHA

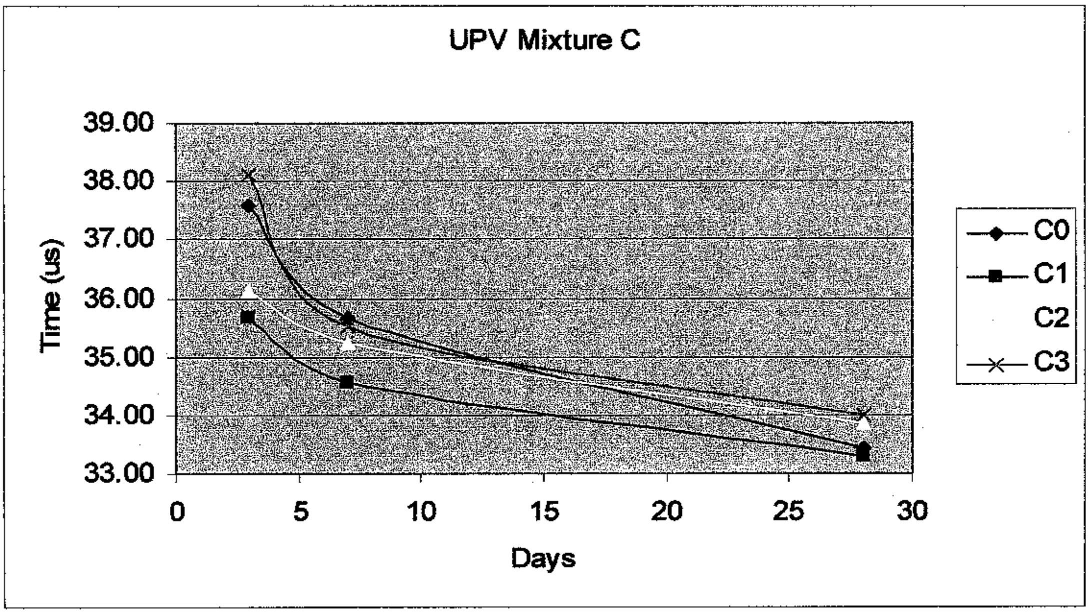


Figure 24 Graphs of UPV test for 0.45 w/c ratio with 0%, 5%, 10%, and 15% of RHA

The RHA strengthen the aggregate-cement paste interface and block the large voids in the hydrated cement paste through pozzolanic reaction. The pozzolanic reactions modifies the pore structure-occupy the empty space in it thus becomes densified. The porosity of cement paste is reduced, and subsequently the pores are refined. This porosity reduced explained the decrease of UPV tests value from 5 % RHA to 15 % RHA usage on Figure 22, Figure 23 and Figure 24. The RHA concretes show a significant reduction in density of the concrete from Day 3 until Day 28.

The compressive strengths for the concretes were increased from Day 3 until Day 28. In practice, strength of concrete at a given age and cured in water at given temperature is assumed to depend primarily on two factors only - w/c ratio and degree of compaction. Assuming full compaction, at a given age, normal temperature, strength of concrete is inversely proportional to w/c ratio - Abram's Law & Feret's Rule.

Fresh cement paste takes a plastic character, but once the paste sets, its apparent or gross volume remains approximately constant. After hydration, mix water takes one of these three forms - combined water, gel water; capillary water w/c ratio determines the porosity of hardened cement paste at any stage of hydration

Other factors that influenced the strength are curing conditions, humidity temperature, water cement ratio, air content, aggregate characteristics: grading, shape, texture, mineralogical, cement: type, composition, fineness, content, porosity, mixing water and method of preparation: batching, mixing, transporting, placing, compaction.

To obtain good quality concrete, placing of concrete will be followed by curing in suitable condition. Curing is the procedure used for promoting the hydration of cement, thus development of strength of concrete. During curing, temperature and movement of moist from and into concrete is controlled.

Some errors may occur during the test. There may be an error while weighing the aggregates, where the required weight is not satisfied. This error probably happens because of the aggregates used are not fully dry. There were also human errors while taking the reading and less of accuracy of the equipment.

CHAPTER 5
CONCLUSION

This project is based on researching the used of rice hush ash in concrete as a cement replacement. The method used is by burning the rice husk at high temperature to get the micro size ash to use in concrete. This research is concentrates on the process of establishing the optimum inclusion of RHA in concrete. From this research, some conclusion can be drawn, namely;

1. The burning procedure adapted (using microwave) was able to extract 89% of SiO_2.
2. Optimum inclusion of RHA that was able to get is 15 % which increased the compressive strength of the concrete up to 50% compared to control mix at 28 days.
3. According to the results of the workability tests, all the replacement degrees of RHA researched achieved similar results. Thus there is no interference of adding RHA in properties of fresh concrete. Superplastisizer is added just to maintain the slump.

REFERENCES

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

2. GulfConstructionOnline.com. Volume XXVI, No 3 March 2005.

3. UK - ICT News 55 - Nov Edition

4. Lin, K. M., The study on the Manufacture of Particle-board Made of China Fir Flakes and Hulls, A Thesis of National Chung-Hsing University for the Degree of Master, Republic of China (1975).

5. Tillman, D. A., Wood as an Energy Resource, Academic Press Inc., New York, U.S.A., pp. 141-159 (1977).

6. Anderson, L. L. and Tillman D.A., Fuels from Waste, Academic Press Inc., New York, U.S.A., pp. 141-159 (1977).

7. Hwang, C. L., and Wu, D. S., Properties of Cement Paste Containing Rice Husk Ash, *ACZ SP-114* (Editor: V. M. Malhotra), pp. 733-765 (1989).

8. Pitt, N., Process for Preparation of Siliceous Ashes, U.S.A. *Patent No. 3959007. (1976).*

9. Longanback, J. R. and Baner, F., *Industrial and Laboratory Pyrolysis,* pp. 476-49 1 (1976).

10. Tsukishima Kikai Co. LTD, Energy from Solid Waste, *(an unpublished paper in Japanese) (I 995).*

11. Schlesinger, M. D., W. S. Scanner and D. E. Wolfson, *Processing Agricultural and Municipal Wastes,* AVI Press, pp. 93-100 (1972).

12. Ankra, K., Studies of Black Silica Produced Under Varying Conditions, *PhD Dissertation,* University of California at Berkeley (1975).

13. Housten, D. F., Rice Chemistry and Technology, *American Association of Cereal Chemists (1972).*

14. Mehta, P. K., Pozzolanic and Cementitious By-products as Mineral Admixtures for Concrete-A Critical Review, *ACZ SP-79,* Detroit, MI pp. 1-46 (1983).

15. Hwang, C. L., Basic Material Properties and Mixture Proportion of High Performance Concrete, *International Workshop on Civil Infrastructural System-Application of Intelligent Systems and Advanced Materials on Bridge Systems, Ed.* by G. C. Lee and K. C. Chang, Taiwan, pp. 207-224 (1994).

16. Johansen, V., and Anderson, P. J., Particle Packing and Concrete Properties, *Material Science of Concrete,* Vol II, Ed. by Skalny, J., and Mindess, S., The American Ceramic Society, US, pp. 111-147 (1989).

17. Mehta, P. K., Monteiro, J. M., *Concrete Structure, Properties, and Materials,* 2nd Ed., Prentice-Hall, Englewood Cliffs, NJ (1993).

18. Narayan P Singhania, S&S Consultants, Institute of Civil Engineers and Surveyors - UK. March, 2004

19. *ASM Handbook®, Vol. 8, Mechanical Testing and Evaluation*, ASM International, Materials Park,

20. Alexander, M.G., and Magee, G.J., (1999) Durability performance of concrete containing condensed silica fume. *Cement and Concrete Research 29, 917-922*

21. Yand, S.J.,Explanatory Study of Catalytic Cracking of Celluloise Biomass (Rice Hull), A Thesis of National Taiwan University for the Degree of Master, Republic of China, pp. 5-7 (1980).

22. Mehta, P.K., "Highly Durable Cement Products Containing Siliceous Ashes", U.S. Patent No. 5, 346, 548, Sept 13, 1994.

23. Zhang, M.H., and V.M. Malhotra,"High-Performance Concrete incorporating Rice-husk Ash as a Supplementary Cementing Material", ACI materials Journal, Vol.93, No.6, 1996, pp. 629-636.

24. Wainwright, P.J. Waste materials in construction wascon 2000.Amsterdam: Pergamon, 2000. p.493-503. Waste Management Series, 1).

25. Institute of Civil Engineers and Surveyors-UK, March 2004.

26. FAOSTAT Database, 2005. FAO, Rome. 20 Dec 2004

27. International Symposium, Cambridge, MA, August 20-21, 1992.