THE EFFECT OF RICE HUSK ASH AND GRINDED RICE HUSK ON THE COMPRESSIVE STRENGTH OF CONCRETE

By

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ABSTRACT

Rice Husk Ash (RHA) is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. Grinded rice husk (GRH) and RHA is an agricultural waste product which is produced in large quantities globally every year. As the rice husk is piling up every day, there is a pressure on rice industries to find a solution for its disposal. Therefore as part of a means to curbing this impending pollution problem. It is most essential to develop eco-friendly uses from rice husk. RHA can be used in concrete to improve its compressive strength while GRH can be used in the production of concrete blocks and bricks. Ordinary Portland cement (OPC) cement was partially replaced by RHA and GRH individually at 10%, 20% and 30% by weight of cement for a specific water/cement ratio. The slump test to determine the workability of the concrete and the compressive test was carried out for 7, 14 and 40 days to measure the compressive strength. The slump value obtained from the control mix was 50 mm while cement partially replaced by RHA at 10 %, 20%, and 30% were 60 mm, 68 mm, and 76 mm respectively and cement partially replaced by GRH at 10 %, 20% and 30% was 32 mm, 15 mm, and 5 mm respectively. The control mix at 40 days has a peak compressive strength of 49.07 N/mm^2 while cement partially replaced by RHA at 10 %, 20%, 30% were 50.24 N/mm^2, 40.53 N/mm^2, and 40.20 N/mm^2 respectively and cement partially replaced by GRH at 10 % was 45.47 N/mm^2 at 40 days. The cement partially replaced by GRH at 20 % and 30% failed at the casting stage. This research concludes that 10% RHA is the optimum content for getting nearly equal strength at 40 days. Replacement of cement with Rice Husk Ash leads to increase in the compressive strength improved the workability and achieved the target strength at 10% replacement for the grade of concrete.

KEY WORDS: Rice husk ash, Grinded rice husk, partial replacement, workability, compressive strength.

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DEDICATION

This project is dedicated to my Jehovah, the giver of all life and to all those I hold dear.

CERTIFICATION

This is to certify that this proposal was written by OTUSANYA, Oluwatimilehin Paul (CVE/11/0377) under my supervision and is approved for its contribution to knowledge and literary presentation. All sources of information are specifically acknowledged by means of references, in partial requirements for the award of Bachelor of Engineering (B.Eng.) degree in Civil Engineering, Federal university Oye-Ekiti, Ekiti, Nigeria.

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CHAPTER ONE

INTRODUCTION

1.1. General Background

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. All the materials required producing such huge quantities of concrete come from the earth's crust. Thus, it depletes its resources every year creating ecological strains. Overall, after the vehicles and pollution caused by factories, cement production is Greatest generation of co_2 and responsible for 50 percent of industrial co_2. Cement forms major part of one of the most highly consumed construction material. However, more than 90 percent of carbon released from the concrete industry is attributed to the production of cement clinker in the cement kiln. So that for each ton of cement produced, 1 to 1.25 tons of co_2 are produced. The amount of co_2 released from the cement kiln is about 940 million tons in 1990, this amount has reached to 1740 million tons in 2005. Muga Helen (2005). Figure 1.1 shows the emission of carbon due to cement over the previous years. On the other hand, human activities on the Earth produce solid waste in considerable quantities of over 2500/MT per year, including industrial wastes, agricultural wastes and wastes from rural and urban societies. Recent technological development has shown that these materials are valuable as inorganic and organic resources and can produce various useful products. Amongst the solid wastes, the most prominent ones are fly ash, blast furnace slag, rice husk, silica fume and demolished construction materials.

From the middle of 20th century, there had been an increase in the consumption of mineral admixtures by the cement and concrete industries. The increasing demand for cement and concrete is met by partial cement replacement. Substantial energy and cost savings can result when industrial by-products are used as a partial replacement for the energy intense Portland cement. The use of by-products is an environmental friendly method of disposal of large quantities of materials that would otherwise pollute land, water and air. Most of the increase in cement demand will be met by the use of supplementary cementing materials.

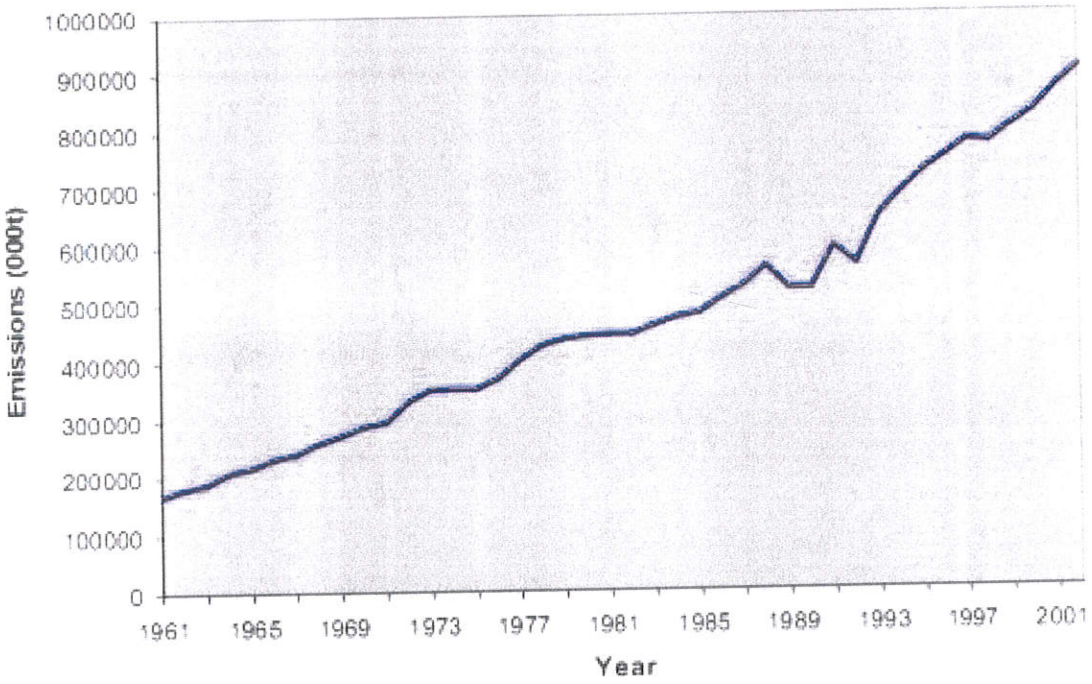

Figure 1.1. World carbon dioxide emission from cement provision (1961-2001)

Pozzolanas are materials containing reactive silica and/or alumina which on their own have little or no binding property but, when mixed with lime in the presence of water, will set and harden like cement. Pozzolanas are an important ingredient in the production of alternative cementing materials to Portland cement (OPC). Alternative cements provide an excellent technical option to OPC at a much lower cost and have the potential to make a significant contribution towards the provision of low-cost building materials and consequently affordable shelter. Pozzolanas can be used in combination with lime and/or OPC. When mixed with lime, pozzolanas will greatly improve the properties of lime-based mortars, concretes and renders for use in a wide range of building applications. Alternatively, they can be blended with OPC to improve the durability of concrete and its workability, and considerably reduce its cost. A wide variety of siliceous or aluminous materials may be pozzolanic, including the ash from a number of agricultural and industrial wastes. Of the agricultural wastes, rice husk has been identified as having the greatest potential as it is widely available and, on burning, produces a relatively large proportion of ash, which contains around 90% silica. Although blended rice husk is not a confirmed pozzolan, we will also be using it as a partial replacement for cement also in this research paper.

RHA has been successfully used as a pozzolan in commercial production in a number of countries including Columbia, Thailand and India. Researchers have revealed that agricultural and industrial related wastes and byproducts are viable replacement materials, especially for cement in concrete examples of such waste are RHA (which has shown prospects when used) and BRH was adopted for investigation. World production of rice husk ash which is an agricultural waste is growing and will be available without any charge. Overall Annual harvest of rice is estimated equivalent to 500 million tons and as regards 20 percent of each grain is its husk and 20 percent of this husk is ash weight so annual production of rice ash shell will be 20 million tons. Indian Institute of Science (2008).

Rice husk ash is considered for its mechanical performance, from study, conventional concrete exhibits increase in compressive strength. Finally, this product can be considered as a promising material Due to availability. Blended rice husk is also obtained through rice milling and it is rice husk that has been crushed into smaller and finer grains. Unlike rice husk ash, blended rice husk does not require burning but it requires a higher degree of accuracy when sieving.

1.2. Aim and objectives

The particular aim of this project is to investigate the feasibility of using rice husk ash and blended rice husk as a partial replacement of cement to produce concrete. With this aim, the research focuses on the following aspects;

Objectives

a. To determine the effect of Rice Husk Ash and Blended Rice Husk on the compressive strength of concrete.

b. To determine the effect of Rice Husk Ash and Blended Rice Husk on the workability of concrete.

c. To compare the result of different tests with varying proportion of rice husk ash and blended rice husk on the concrete compressive strength and workability with 0% concrete (control mix).

1.3. Justification

Rice husk ash is a by-product which can be abundantly found in this country. Therefore, using rice husk ash should promise some advantages in reduce the environmental problems. Also due to high exchange rate in Nigeria cement has become more expensive and continues to increase in price. The partial replacement of cement with pozzolans brings about a reduction in construction cost which makes construction more economical.

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews concrete with properties such as mechanical properties like concrete compressive strength, in terms of the mix composition, requirements, and principles of production. When both cement and supplementary cementing material (SCM) used in concrete mixtures, concrete mixtures show a high autogenous shrinkage and specific improvements in properties because of this. Some of the commonly used supplementary cementing materials are fly ash, Silica Fume (SF), Ground Granulated Blast Furnace Slag (GGBFS) and Rice Husk Ash (RHA) etc. Due to the limitations in terms of cost and availability, RHA has been considered a very promising candidate amongst others mentioned above.

2.1. Concrete

A composite material that consists essentially of a binding medium, such as a mixture of portland cement and water, within which are embedded particles or fragments of aggregate, usually a combination of fine and coarse aggregate. Concrete is by far the most versatile and most widely used construction material worldwide. It can be engineered to satisfy a wide range of performance specifications, unlike other building materials, such as natural stone or steel, which generally have to be used as they are. Because the tensile strength of concrete is much lower than its compressive strength, it is typically reinforced with steel bars, in which case it is known as reinforced concrete.

A composite material is made up of various constituents. The properties and characteristics of the composite are functions of the constituent materials' properties as well as the various mix proportions. Concrete is made of the following materials.

1. **Cement.**

There are many different kinds of cements. In concrete, the most commonly used is Portland cement, a hydraulic cement which sets and hardens by chemical reaction with water and is capable of doing so under water. Cement is the "glue" that binds the concrete ingredients together and is instrumental for the strength of the composite. Although cements and concrete have been around for thousands of years, modern portland cement was invented in 1824 by Joseph Aspdin of Leeds, England. Portland cement is made up primarily of four mineral components (tricalcium silicate, dicalcium silicate, tricalcium aluminate, and tetracalcium alu minoferrite), each of which has its own hydration characteristics. By changing the relative proportions of these components, cement manufacturers can control the properties of the product.

2. **Aggregate**.

The aggregate is a granular material, such as sand, gravel, crushed stone, or iron-blast furnace slag. It is graded by passing it through a set of sieves with progressively smaller mesh sizes. All material that passes through sieve #4 [0.187 in. (4.75 mm) openings] is conventionally referred to as fine aggregate or sand, while all material that is retained on the #4 sieve is referred to as coarse aggregate, gravel, or stone. By carefully grading the material and selecting an optimal particle size distribution, a maximum packing density can be achieved, where the smaller particles fill the void spaces between the larger particles.

3. **Admixtures**.

While aggregate, cement, and water are the main ingredients of concrete, there are a large number of mineral and chemical admixtures that may be added to the concrete.

2.2. Properties of Fresh Concrete

Concrete remains in its fresh state from the time it is mixed until it sets. During this time the concrete is handled, transported, placed and compacted. Properties of concrete in its fresh state are very important because the influence the quality of the hardened concrete. The fresh concrete has the following properties.

1. **Consistency**

Consistency of a concrete mix is a measure of the stiffness or sloppiness or fluidity of the mix. For effective handling, placing and compacting the concrete, consistency must be the same for each batch. It is therefore necessary to measure consistency of concrete at regular intervals. Slump test is commonly used to measure consistency of concrete.

2. Workability

The workability of a concrete mix is the relative ease with which concrete can be placed, compacted and finished without separation or segregation of the individual materials. Workability is not the same thing as consistency. Mixes with the same consistency can have different workability, if they are made with different sizes of stone – the smaller the stone the more workable the concrete.

It is not possible to measure workability but the slump test, together with an assessment of properties like stone content, cohesiveness and plasticity, gives a useful indication.

3. Settlement and Bleeding

Cement and aggregate particles have densities about three times that of water. In fresh concrete they consequently tend to settle and displace mixing water which migrates upward and may collect on the top surface of the concrete. This upward movement of mixing water is known as bleeding; water that separates from the rest of the concrete is called bleed water.

4. Plastic Shrinkage

If water is removed from the compacted concrete before it sets, the volume of the concrete is reduced by the amount of water removed. This volume reduction is called plastic shrinkage. Water may be removed from the plastic concrete by evaporation or by being absorbed by dry surfaces such as soil or old concrete or by the dry wooden form work.

5. Slump Loss

From the time of mixing, fresh concrete gradually loses consistency. This gives rise to the problems only if the concrete becomes too stiff to handle, place and compact properly. Slump loss in concrete is caused due to the following reasons.

i. Hydration of cement (generating more heat)
ii. Loss of water by evaporation Absorption of water by dry aggregates
iii. Absorption of water by surfaces in contact with the concrete.

2.3. Properties of Hardened Concrete

Fully cured, hardened concrete must be strong enough to withstand the structural and service loads which will be applied to it and must be durable enough to withstand the environmental exposure for which it is designed. If concrete is made with high-quality materials and is properly proportioned, mixed, handled, placed and finished, it will be the strongest and durable building material. Below are the properties of hardened concrete:-

1. Strength

When we refer to concrete strength, we generally talk about compressive strength of concrete. Because, concrete is strong in compression but relatively weak in tension and bending. Concrete compressive strength is measured in pounds per square inch (psi). Compressive strength mostly depends upon amount and type of cement used in concrete mix. It is also affected by the water-cement ratio, mixing method, placing and curing. Concrete tensile strength ranges from 7% to 1 2% of compressive strength. Both tensile strength and bending strength can be increased by adding reinforcement.

2. Creep

Deformation of concrete structure under sustained load is defined as concrete creep. Long term pressure or stress on concrete can make it change shape. This deformation usually occurs in the direction the force is applied.

3. Durability

This might be defined as the ability to maintain satisfactory performance over and extended service life. The design service life of most buildings is often 30 years, although buildings often last 50 to 100 years. Most concrete buildings are demolished due to obsolescence rather than deterioration. Different concretes require different degrees of durability depending on the exposure environment and properties desired. Appropriate concrete ingredients, mix proportions, finishes and curing practices can be adjusted on the basis of required durability of concrete.

4. Shrinkage

Shrinkage is the volume decrease of concrete caused by drying and chemical changes. In another word, the reduction of volume for the setting and hardening of concrete is defined as shrinkage.

5. Modulus of Elasticity

The modulus of Elasticity of concrete depends on the Modulus of Elasticity of the concrete ingredients and their mix proportions.

6. Water tightness

Another property of concrete is water tightness. Sometime, it's called impermeability of concrete. Water tightness of concrete is directly related to the durability of concrete. The lesser the permeability, the more the durability of concrete. Now the question is, what is the permeability of concrete? In simple word, the capability of penetrating outer media into concrete is the permeability of concrete. Outer media means water, chemicals, sulphates, etc.

2.4. Pozzolan

Pozzolans and supplementary cementitious materials (SCMs), either natural or artificial, are often used as a cement replacement or as an enhancement in concrete. Physical and chemical properties of a material determine their pozzolanic or cementitious properties. A pozzolan has been defined as a siliceous or aluminosiliceous material that, in finely divided form and in the presence of moisture, chemically reacts with the calcium hydroxide released by the hydration of Portland cement to form calcium silicate hydrate and other cementitious compounds. Therefore, natural pozzolana cement could be produced from any biomaterials with high silica content.

Pozzolans fall into two categories, either natural or artificial, depending on their provenance. Natural pozzolans are either raw or calcined natural materials—such as volcanic ash, opaline chert, tuff, some shale, or some diatomaceous earth—that have pozzolanic properties (American Concrete Institute 2000). The amount of amorphous or unstructured material often determines the reactivity of the natural pozzolans.

There are three categories of natural pozzolans:

1 Volcanic ash, called tuff when indurated, in which the amorphous constituent is a glass produced by rapid cooling of magma.

2 Those derived from rocks or earth in which the silica is mainly opal, and diatomaceous earth.

3 Some clays and shales.

2.5. Pozzolanic Reaction

A pozzolanic reaction occurs when a siliceous or aluminous material get in touch with calcium hydroxide in the presence of humidity to form compounds exhibiting cementitious properties. In the cement hydration development, the calcium silicate hydrate (C-S-H) and calcium hydroxide (Ca (OH) 2, or CH) are released within the hydration of two main components of cement namely tricalcium silicate (C3S) and dicalcium silicate (C2S) where C, S represent CaO and SiO2 Hydration of C3S, C2S also C3A and C4AF (A and F symbolize Al_2O_3 and Fe_2O_3) respectively, is important.

2.6. Benefit of Pozzolans

Pozzolans not only strengthen and seal the concrete, they have many other beneficial features you will realize the moment you purchase them or add them to the mix. All of the below benefits apply to fly ash and rice husk ash, and most of them to silica fume as well. Spherical Shape: Fly ash (FA) and rice husk ash (RHA) particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures (Schneider *et al.*, 2011).

1. **Ball Bearing Effect:** The "ball-bearing" effect of FA and RHA particles creates a lubricating action when concrete is in its plastic state.
2. **Economic Savings:** Pozzolans replace higher volumes of the more costly cement, with typically less cost per volume.

3. **Higher Strength:** Pozzolans continue to combine with free lime, increasing structural strength over time.
4. **Decreased Permeability:** Increased density and long-term pozzolanic action, which ties up free lime, results in fewer bleed channels and decreases permeability.
5. **Increased Durability:** Dense pozzolan concrete helps keep aggressive compounds on the surface, where destructive action is lessened. Pozzolan concrete is also more resistant to attack by sulfate, mild acid, soft (lime hungry) water, and seawater.
6. **Reduced Sulfate Attack:** Pozzolans tie up free lime that otherwise could combine with sulfate to create destructive expansion.
7. **Reduced Efflorescence:** Pozzolans chemically bind free lime and salts that can create efflorescence. Denser concrete, due to pozzolans, holds efflorescence-producing compounds on the inside.
8. **Reduced Shrinkage:** The largest contributor to drying shrinkage is water content. The lubricating action of FA and RHA reduces the need for water and therefore also drying shrinkage.
9. **Reduced Volume:** As pozzolans can in certain cases substitute for up to four times the mass of cement, besides making the same amount of concrete harder than without pozzolans, less voluminous structures are able to bear the same load.
10. **Reduced Heat of Hydration:** The pozzolanic reaction between pozzolan and lime generates less heat, resulting in reduced thermal cracking when pozzolans are used to replace Portland cement.
11. **Reduced Alkali Silica Reactivity:** Pozzolans combine with alkalis from cement that might otherwise combine with silica from aggregates, which would cause potentially destructive expansion.
12. **Workability:** Concrete enhanced with FA and RHA is easier to place, with less effort, responding better to vibration to fill forms more completely.
13. **Ease of Pumping:** Pumping of FA and RHA concrete requires less energy, therefore longer pumping distances are possible.
14. **Improved Finishing:** Sharp, clear architectural definition is easier to achieve with FA and RHA concrete, with less worry about in-place integrity.

15. **Reduced Bleeding:** Fewer bleed channels decreases porosity and chemical attack. Bleed streaking is reduced for architectural finishes. Improved paste to aggregate contact results in enhanced bond strengths.
16. **Reduced Segregation:** Improved cohesiveness of pozzolan concrete reduces segregation that otherwise could lead to rock pockets and blemishes.
17. **Reduced Slump Loss:** More dependable concrete allows for longer working time especially important in hot weather.
18. **Very low Chloride Ion Diffusion:** Pozzolans make concrete more resistant to salt water (seawater).
19. **Improved Water Tightness:** The formation of expansive gels effectively seals the concrete.
20. **Resistance to Freeze-Thaw:** As water doesn¹t penetrate the hardened concrete, freezing can¹t cause destructive expansion.
21. **Resistance to Adverse Chemical Reactions:** The example of Dynastone shows how pozzolans can protect against strong acids.

2.7. Definition of Rice Husk Ash and Notable Works Done Carried Out on It

Rice Husk Ash (RHA) which is an agricultural by-product has been reported to be a good pozzolan by numerous researchers. Mehta and Pirth, (2000) investigated the use of RHA to reduce temperature in high strength mass concrete and got result showing that RHA is very effective in reducing the temperature of mass concrete compared to OPC concrete. Malhotra and Mehta (2004) later reported that ground RHA with finer particle size than OPC improves concrete properties, including that higher substitution amounts results in lower water absorption values and the addition of RHA causes an increment in the compressive strength. Cordeiro, Filho and Fairbarn (2009) carried out elaborate studies of Brazilian RHA and Rice Straw Ash (RSA) and demonstrated that grinding increases the pozzolanicity of RHA and that high strength of RHA, RSA concrete makes production of blocks with good bearing strength in a rural setting possible. Their study showed that combination of RHA or RSA with lime produces a weak cementitous material which could however be used to stabilize laterite and improve the bearing strength of the material. Habeeb and Fayyadh (2009) investigated the influence of RHA average particle size on the properties of concrete and found out that at early ages the strength was comparable, while at the age of 28 days, finer RHA exhibited higher strength than the sample with coarser RHA. Rukzon, Chindaprasirt and Mahachai (2009) further studied the effect of grinding on the chemical and physical properties of rice husk ash and the effect of RHA fineness on properties o mortar and found that pozzolans with finer particles had greater pozzolanic reaction. Many works have been done in the area of finding replacement for cement (blended cement or pozzolan cement). Bakker (1999) identified the two mostly used pozzolans in Europe as blast furnace slag and fly ash being waste products from iron rolling industries and electricity generating stations using coal.

In Sugita et al. (1997), the use of rice husk ash with ordinary Portland cement increases the compressive strength of concrete at 28 days and the concrete produced is resistant to acid attack. The increase in strength is attributed to the water absorption capability of the rice husk ash. In Udoeyo (2002), concrete with sawdust ash as pozzolanic material gain strength rapidly at later ages. In Adesanya (1996), corn cob ash was used as partial replacement for cement. The study showed that replacing 50% by weight of ordinary Portland cement with corn cob ash produced stabilized laterite and clay with greater strength, lower water absorption as well as lower thermal conductivity than the one stabilized with only ordinary portland cement. Furthermore, concrete and mortar mixes produced by replacing 20% by weight of ordinary portland cement with corn cob ash enhanced the durability of the specimens with no significant difference in the compressive strength of concrete produced.

Using RHA as partial replacement for cement in concrete will produce a greater volume of cementitious material in the concrete. Addition of RHA to the mix caused a significant decrease in the slump compared with the mix made of only OPC. Thus, RHA requires more water to achieve the same consistency. The water absorbing capacity of RHA was found to be its principal physical property which significantly affects the workability of OPC/RHA concrete.

2.8. Uses of Rice Husk Ash

Rice husk ash contains over 90% silica and can be an economically viable raw material for the production of silicates and silica. It has unique properties which makes it a valuable raw material with many uses. (Prasad et al. 2006). It's used in the following major works;

1. Rice industry
2. Power plant
3. Cement and concrete industry
4. Brick production
5. Briquette production
6. Waste water treatment plant
7. Agricultural industry
8. Cellulosic ethanol production

2.9. Application of Rice Husk Ash

1. Aggregates and fillers for concrete and board production.
2. Economical substitute for micro silica / silica fumes absorbents for oils and chemicals
3. Soil ameliorants (An ameliorant is something that helps improve soil drainage, slows drainage, breaks up soil or binds soil, feeds and improves structure etc.)
4. As a source of silicon
5. As insulation powder in steel mills
6. As repellents in the form of "vinegar-tar"
7. As a release agent in the ceramics industry
8. As an insulation material for homes and refrigerants.

2.10. Physical Structure of Rice

A rice grain is made up of an outside husk layer, a bran layer, and the endosperm. The husk layer (lemma and palea) accounts for 20% of the weight of paddy and helps protect the grain kernel from insect and fungal attack. When the husk is removed, the rice is called brown rice. Brown rice contains the bran layer and the endosperm. The bran layer is made up of the pericarp and testa, the aluerone layer and the embryo. The degree to which this bran layer is removed is known as the milling degree. The desired amount of bran removed depends on the country. In Japan, the aluerone layer is often not removed however in many other countries all bran layers are removed to give very highly polished rice. The storage life of milled rice is improved when all of the bran layers are removed. (Cand.com 2008). Table 2.1 shows the physical composition of rice.

Table 2.1. Physical composition of rice.

Physical characteristic	Percentage
Paddy	100
Husk	80
Brown rice	20
Meal Pericarp and testa (5-6%) *Aluerone (1%)* *Embryo (3%)*	8-10
White rice	70-72

Source: Consequences of sulphate attack on concrete (Currey *et al,* 1984)

2.11. Chemical Composition of Milled Rice

Rice at 12% moisture contains approximately 80% starch and 7% protein. (Currey, 1984) Starch occurs in the endosperm as small many-sided granules while protein is present as particles that lie between the starch granules. Rice grain also contains sugars, fat, dietary fibre and minerals. Table 2.2 shows the chemical composition of rice and bran.

Table 2.2. Chemical composition of rice and bran.

	Brown rice	White rice	Bran
Water(%)	13-14	13-14	13-14
Starch(%)	68-70	80	9
Amylose	28-30	33	6
Protein(%)	6-8	6-7	14
Fat	3	1	20
Fiber	2-3	0.5	25
Crude ash	1-1.5	0.5	9-10

Source: Consequences of sulphate attack on concrete (Currey *et al,* 1984)

2.12. Rice Milling

The objective of a rice milling system is to remove the husk and the bran layers from paddy rice to produce whole white rice kernels that are sufficiently milled, free of impurities and contain a minimum number of broken kernels. Plate 2.1 and figure 2.1 shows how rice is milled and the rice produce from the mill.

The milling yield and quality of rice is dependent on the quality of the paddy, the milling equipment used and the skill of the mill operator.

Plate 2.1. Rice milling

Source: Electronic Journal of Practices and Technologies (Pham, 2006)

According to (Pham Van Hanh,2008), modern rice milling processes consist of:

1. Pre-cleaning - removing all impurities and unfilled grains from the paddy
2. Husking-removing the husk from the paddy.
3. Husk aspiration-separating the husk from the brown rice/unhusked paddy.
4. Paddy separation-separating the unhusked paddy from the brown rice.
5. De-stoning - separating small stones from the brown rice.
6. Whitening - removing all or part of the bran layer and germ from the brown rice Polishing - improving the appearance of milled rice by removing remaining particles and by polishing the exterior of the milled kernel.
7. Sifting - separating small impurities or chips from the milled rice.
8. Length grading - separating small and large brokens from the head rice.
9. Blending - mix head rice with predetermined amount of brokens, as required by the customer.
10. Weighing and bagging - preparing milled rice for transport to the customer.

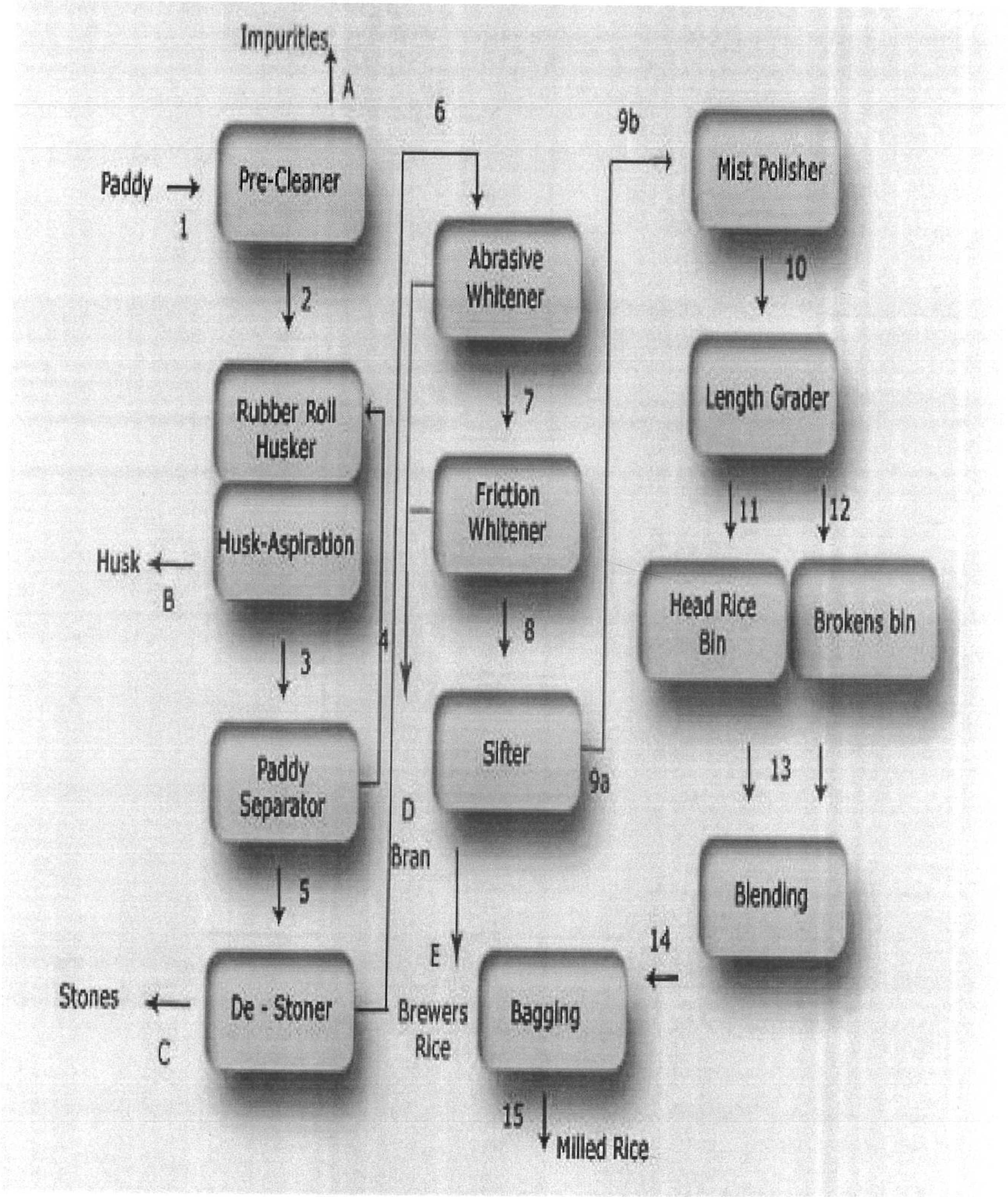

Figure 2.1. rice milling processes (Pham Van Hanh,2008).

2.13. Production of Rice Husk Ash

Rice husk is burnt approximately 48 hours under controlled combustion process. The burning temperature was within the range of 600 to 850 degrees. The ash obtained is ground in a ball mill for 30 minutes and its color was seen as grey. This RHA in turn contains around 85%-90% amorphous silica. So for every 1000 kg of paddy milled, about 220 kg (22%) of husk is produced, and when this husk is burnt in the boilers, about 55 kg (25%) of RHA is generated. (Tashima et al., 2004).

Rice Husk can contribute about 20% of its weight to Rice Husk Ash (RHA) after incineration (Anwar et al., 2001). RHA is a highly pozzolanic material (Tashima et al., 2004). The non-crystalline silica and high specific surface area of the RHA are responsible for its high pozzolanic reactivity. RHA has been used in lime pozzolana mixes and could be a suitable partly replacement for Portland cement (Smith et al., 1986; Zhang et al., 1996; Nicole et al., 2000; Sakr 2006; Sata et al., 2007; etc). RHA is a highly pozzolanic material (Tashima et al., 2004). The non-crystalline silica and high specific surface area of the RHA are responsible for its high pozzolanic reactivity. RHA has been used in lime pozzolana mixes and could be a suitable partly replacement for Portland cement (Smith et al., 1986; Zhang et al., 1996; Nicole et al., 2000; Sakr 2006; Sata et al., 2007; etc). RHA concrete is like fly ash/slag concrete with regard to its strength development but with a higher pozzolanic activity it helps the pozzolanic reactions occur at early ages rather than later as is the case with other replacement cementing materials (Molhotra, 1993). Plate 2.3 and plate 2.4 depict the incineration process and rice husk ash obtained from the burning of rice husk.

Furthermore, chemical analysis showed that silicon content is different at various regions in rice husk with 45.16, 2.27 and 27.27% for the husk external surface, husk interior and husk internal surface, respectively. It must be noted that these chemical composition values may vary depending on location where rice is grown. The production of a hybrid cement from the mixture of Portland cement and RHA pozzolan is not a new discovery. Previous studies had considered its uses for sandcrete blocks production and concrete. However, information on its suitability for the production of cement bonded composites has not been reported in published articles.

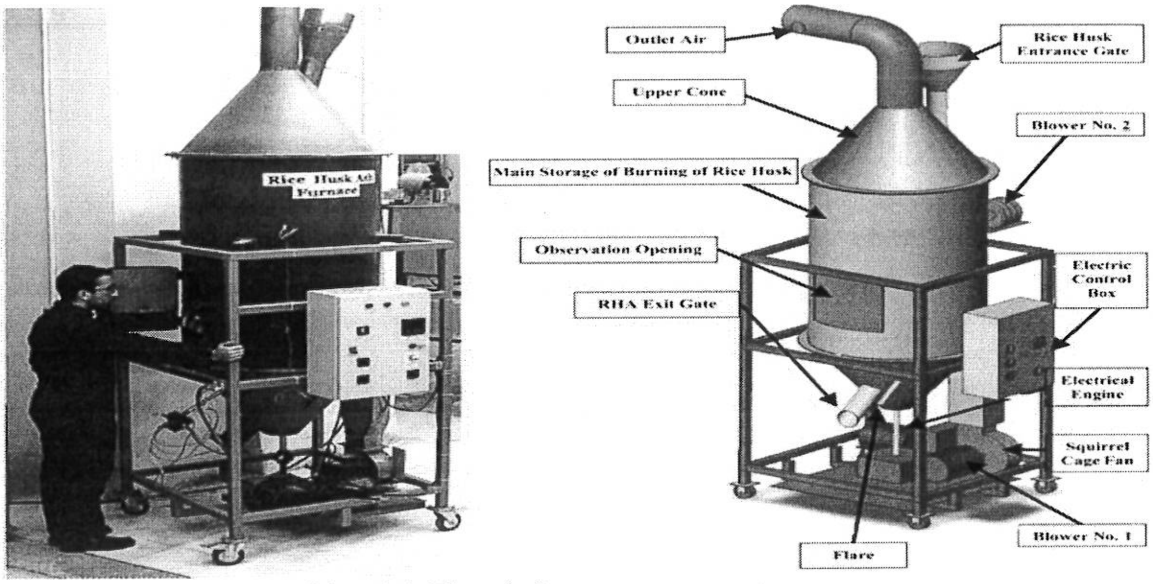

Plate 2.3. Electric furnace component

Plate 2.4. Burnt rice husk

2.14. Properties of Rice Husk Ash

The typical chemical composition and physical properties of RHA are given in Table (Mehta 1992; Bui et al., 2005; Zhang et al., 1996). Table 2.3 and table 2.4 show the chemical and physical composition of rice husk ash

Table 2.3. Chemical properties of rice husk ash

Constituent	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Loss on
Mehta (1992)	87.2	0.15	016	0.55	0.35	0.24	1.12	3.68	8.55
Zhang et al. (1996)	87.3	0.15	0.16	0.55	0.35	0.24	1.12	3.68	8.55
Bui et al. (2005)	86.9	0.84	0.73	1.40	0.57	0.11	2.46	-----	5.14

Table 2.4. Physical properties of rice husk ash.

Serial No.	**Particulars**	**Properties**
1	Color	Gray
2	Shape Texture	Irregular
3	Mineralogy	Non crystalline
4	Particle Size	< 45 micron
5	Odour	Odourless
6	Specific gravity	2.3
7	Appearance	Very fine
8	Mean particle size (µm)	7.4
9	Fineness passing 45µm(%)	

There are so many reasons associated with rice husk for not being utilized effectively, (Fang et. al, 2004) suggested the following reasons;

1. Lack awareness of its potential to a farmers and industry persons,
2. Insufficient information about proper use,
3. Socio-economic problems,
4. Penetration of technology,
5. Lack of interest,
6. Lack of environmental concerns,
7. Inefficiency of information transfer, etc.

Solution to the problems associated with utilization of this solid waste needs to be worked out not only from the quality point of view but quantitatively as well, because quantity of rice husk produced is very large. But. the most promising and profitable use of this biomass is its use for the electrical energy generation in efficient way, besides this using rice husk in bio-power generation adopting efficient equipment gives very valuable by product(Fang at. el, 2004).

2.14. Advantages of Using Rice Husk Ash in Concrete

The use of RHA in concrete has been associated with the following essential assets:

1. Increased compressive and flexural strengths (Zhang et al., 1996)
2. Reduced amount of super plasticizer
3. Reduced potential for efflorescence due to reduced calcium hydracids (Chindaprasirt et al., 2007)
4. Reduced permeability (Zhang et al., 1996)
5. Reduced effects of alkali-silica reactivity (ASR)
6. Reduced shrinkage due to particle packing, making concrete denser (Habeeb et al., 2009)
7. Increased resistance to chemical attack (Chindaprasirt et al., 2007)
8. Increased durability

9. Enhanced workability of concrete (Habeeb et al., 2009)
10. Reduced heat gain through the walls of buildings

2.15. Application of Using Rice Husk Ash in Concrete

The employment of RHA in cement and concrete has gained considerable importance because of the requirements of environmental safety and more durable construction in the future. The use of RHA as partial replacement of cement in mortar and concrete has been extensively investigated in recent years. This literature review clearly demonstrates that RHA is an effective pozzolan which can contribute to mechanical properties of concrete. RHA blended concrete can decrease the temperature effect that occurs during the cement hydration. RHA blended concrete can improve the workability of concrete compared to OPC. It can also increase the initial and also final setting time of cement pastes. Additionally, RHA blended concrete can decrease the total porosity of concrete and modifies the pore structure of the cement, mortar, and concrete, and significantly reduce the permeability which allows the influence of harmful ions leading to the deterioration of the concrete matrix. RHA blended concrete can improve the compressive strength as well as the tensile and flexural strength of concrete. RHA helps in enhancing the early age mechanical properties as well as long-term strength properties of cement concrete.

RHA replacement level up to 40%. Substitution of RHA has shown to increase the chemical resistance of such mortars over those made with plain Portland cement. Incorporation of RHA as a partial cement replacement between 12% and 15% may be sufficient to control deleterious expansion due to alkali-silica reaction in concrete, depending on the nature of the aggregate. It can be concluded that the use of rice husk ash leads to enhanced resistance to segregation of fresh concrete compared to a control mixture with Portland cement alone Generally, around 7 MPa strength is achieved at 14 days with mix proportion of 20:80 ratio of lime: RHA is a binder material along with some admixtures. Amorphous RHA is preferred for its use in the concrete manufacture. It is due to high pozzolanic property of amorphous RHA.

RHA can significantly reduce the mortar-bar expansion. Finally, this literature search showed that the mechanical properties of concrete are enhanced when the substitution of Portland cement was done by RHA. RHA concrete is like fly ash/slag concrete with regard to its strength development but with a higher pozzolanic activity it helps the pozzolanic reactions occur at early ages rather than later as **Reaction mechanism.**

2.16. Performance of Rice Husk Concrete Expose to Industrial Environment

A comprehensive programme by (Chindaprasirt et al., 2007) to investigate the performance of plane concrete and rice husk ash concrete expose to industrial environment was chalked out in this short duration study. The programme is composed of compressive strength study, weight loss study, effect of carbonation, PH test study and ultrasonic pulse velocity test study investigation to study the behavior of plain concrete having mix proportion 1:1.35:3 and rice husk ash concrete having a specified weight of rice husk ash exposed to industrial environment (5%H2SO4, 55HIL, 10%(NH4)2SO4 and 10%NaOH solution) for 28 days revealed that plain concrete cube deteriorated more than rice husk concrete. The strength of PCC exposed to aggressive medium reduced significantly. Ten percent replacement of cement by rice husk ash made the concrete impervious and enhances the resistance of concrete to different environment.

The compressive strength and durability of concrete increased significantly when 10% RHA (by weight) in place of cement was added. The reduction in strength was mainly due to expansive salt formation and weakening of bonds.

According to (Godwin A. Akeke, et.al.2009) from the experiments and analysis of results of findings in his research work, the following facts are established about RHA Concrete. RHA is a super pozzolan and its use in Civil Construction, besides reducing environmental polluters factors, will bring several improvements to concrete Characteristics. The compressive strength and workability tests suggested that RHA could be substituted for OPC at up to 25% in the production of concrete with no loss in workability or strength. Based on the results of split Tensile Strength test, it is convenient to state that there is no Substantial increase in Tensile Strength due to the addition of RHA. The Flexural strength studies indicated that there is a marginal improvement with 10 to 25% RHA replacement levels. Rice Husk Ash concrete possess a number of good qualities that make a durable and good structural concrete for both short term and long term considerations. It is good for structural concrete at 10% replacement level.

Based on experiments and test results on fresh & hardened concrete by (Godwin A. Akeke, et.al.2009)

1. Improvement in Fresh Concrete Properties:

    a. Due to addition of rice Husk ash, concrete becomes cohesive and more plastic and thus permits easier placing and finishing of concrete. It also increases workability of concrete.

    b. The bulk density of RHA concrete is reducing with increase in RHA content.

2. Compressive Strength:

    a. Due to addition of RHA it is observed that early strength gain is slightly increasing with addition of 10%, 20% & 30% RHA in normal concrete at 7 days.
    b. But in 28 days tests results it is found that with addition of 20% RHA in normal concrete strength is running parallel or more than of normal concrete. Thus 20% RHA is the optimum content for getting nearly equal strength at 28 days.
    c. As the replacement of cement by RHA in concrete increases, the workability of concrete decreases.
    d. Replacement of cement with Rice Husk Ash leads to increase in the compressive strength improved the workability and achieved the target strength at 20% replacement for the grade of concrete.
    e. The pozzolonic activity of rice husk ash is not only effective in enhance the concrete strength, but also in improving the impermeability characteristics of concrete.
    f. The optimum replacement level of Rice Husk Ash is found to be to20% for M30 grade of concrete.

g. The use of rice husk ash as an alternative for cement & as additive to reduce corrosion and increase durability of concrete strength.
h. The utilization of RHA holds promising prospects in the country because it softens the impact on the environment & capital cost of the structure.
i. RHA is also use for manufacturing load bearing blocks bricks tiles in low cost.
j. As the Rice Husk Ash is waste material, it reduces the cost of construction.
k. It helps in reducing the pollution in environment.

From his entire experimental work Makarand, 2014 concluded that mix M2 (M0+20% RHA is the best combination among all mixes, which gives max, tensile, flexure & compression strength over normal concrete.

CHAPTER THREE

MATERIALS AND METHOD

3.1. Experimental Materials

1. Rice husk ash
2. Grinded rice husk
3. Cement
4. Fine aggregates
5. Coarse aggregates
6. Water

3.2. Flow Chart

According to Fig 3.1 the whole research process went as followed;

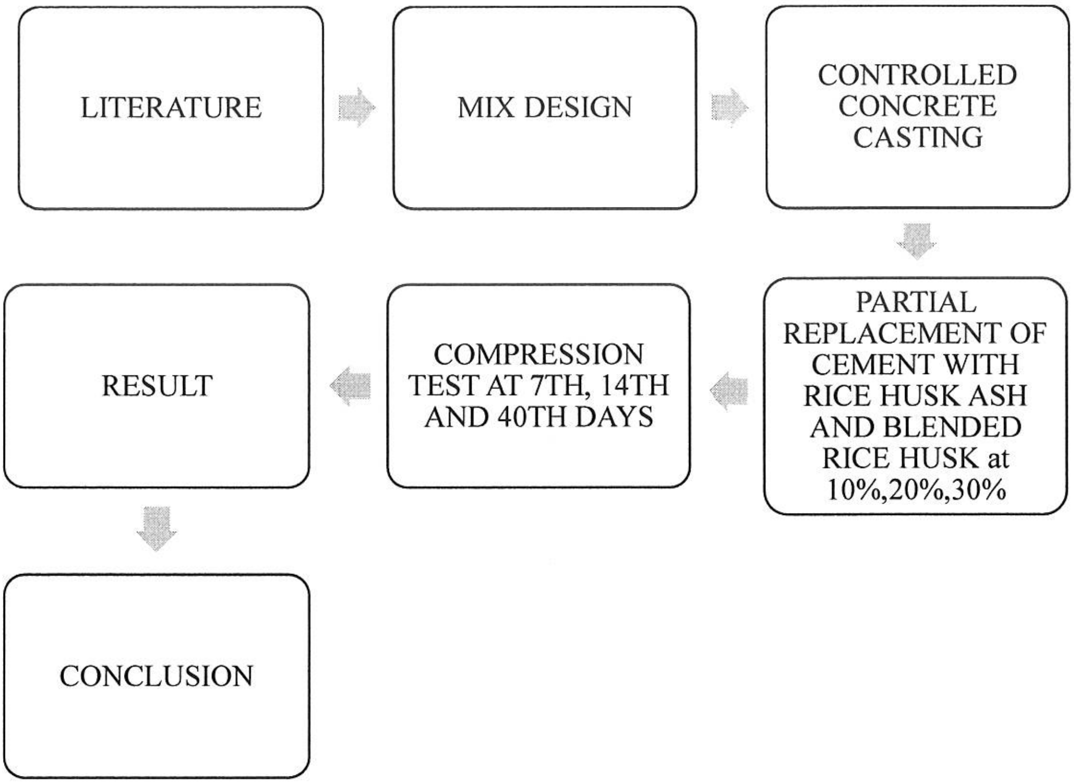

Fig 3.1 Flow chart depicting the methodology

3.3. Production of RHA and BRH

The rice husk used in this work was collected from rice paddy industry in Ikole, Ekiti, Nigeria. To obtain it's ash it was then burnt in the laboratory by using a Ferro-cement furnace (Plate 3.2) with incinerating temperature of about 700°C. The ash was then collected and sieved. Plate 3.1shows how the blended rice husk was blended using a grinder.

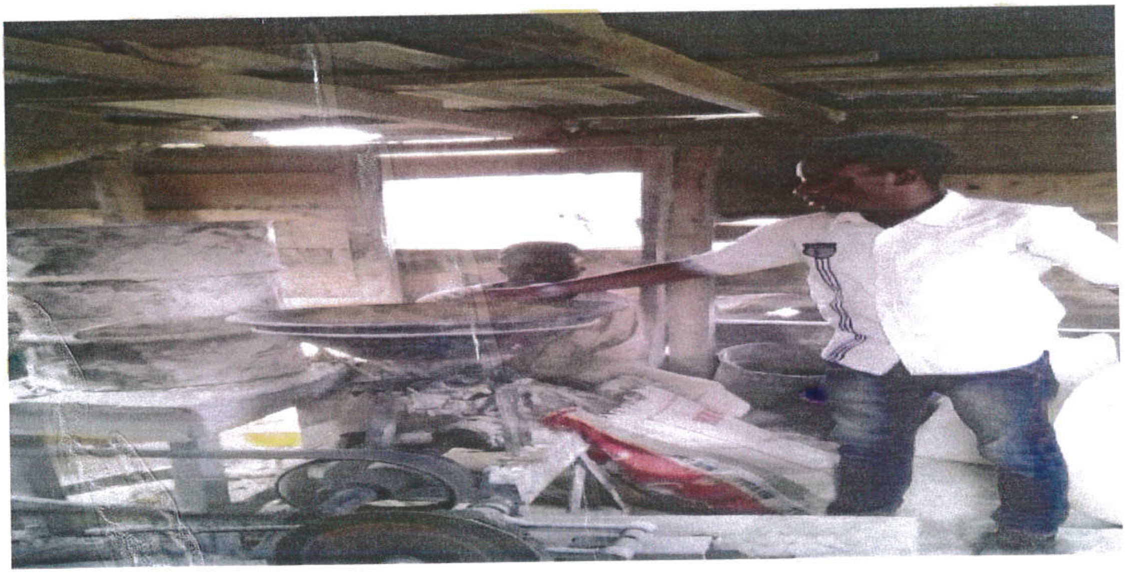

Plate 3.1 Grinding machine

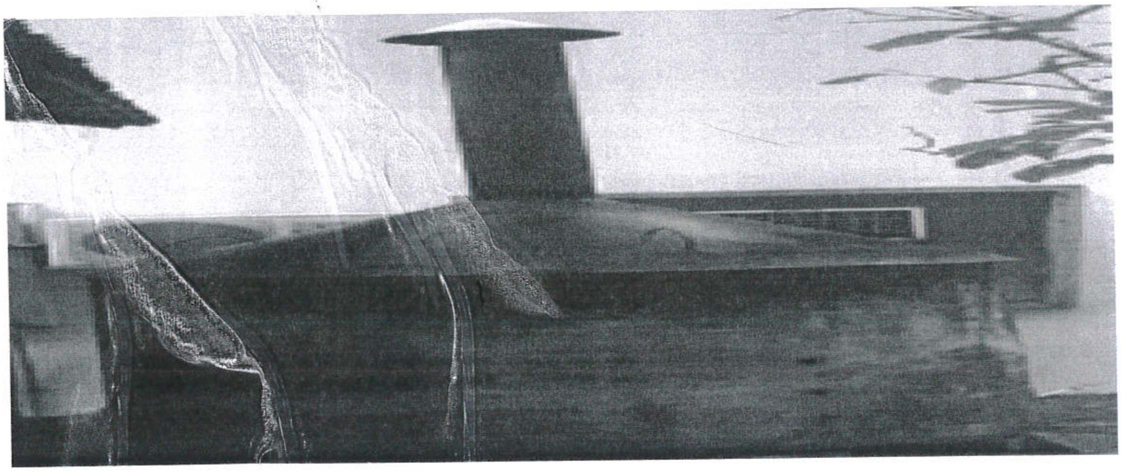

Plate 3.2 Ferro-cement furnace

3.4. Mix proportions of concrete cubes mixed with RHA and BRH

In this work, seven batches of concrete were produced with varying amounts of Rice Husk Ash (RHA) and Blended Rice Husk (BRH) substituted for Ordinary Portland Cement (OPC). There was a control group with no RHA i.e. 0 % replacement (also known as control mix), then followed by 10% replacement, 20% replacement, and 30% replacement of RHA and BRH respectively as shown in table 3.1. This is important because it fits the conditions of rural and developing countries, where cement is expensive and rice cultivation is predominant.

Table 3.1 Quantities of Materials per Cubic meter of Concrete for various Batch

Mix No	**% Replacement**	**Cement (kg)**	**RHA (kg)**	**BRH (kg)**	**CA (kg)**	**FA (kg)**	**Water-cement Ratio**
1	0%	14.46	-	-	33.12	25.31	0.45
2	10% RHA	13.19	1.80	-	30.9	24.53	0.45
3	20% RHA	10.96	3.85	-	33.37	24.3	0.45
4	30% RHA	10.20	5.38	-	34	23.31	0.45
5	10% BRH	11.46	-	3.63	33.2	24.6	0.45

3.5. Preparation of concrete cubes for crushing

The steps required for the casting and the preparation of concrete cubes for casting are as follows;

i. The cement was mixed with the fine aggregate on a water tight none-absorbent platform until the mixture was thoroughly blended and of uniform color.

ii. The coarse aggregate was added and mixed with cement and fine aggregate until the coarse aggregate was uniformly distributed throughout the batch.

iii. Water was then added and mixed until the concrete appears to be homogeneous and of the desired consistency

i. The moulds were cleaned and oil was applied.

ii. The concrete was filled into the moulds in layers approximately 50 mm thick.

iii. Each layer was compacted with not less than 35strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end) so as not to have any voids.

iv. The top surface was leveled and smoothened with a trowel by putting cement paste and spreading smoothly on whole area of specimen.

v. The specimens were marked for identification during crushing.

The test specimens were stored in moist air for 24hours and after this period removed from the moulds and kept submerged in clear fresh water until taken out prior to test. Plate 3.6 to plate 3.9 shows the preparation of materials for the casting process and the casting of the concrete cubes.

Plate 3.3 Weighing of the materials for casting

Plate 3.4 Casting of concrete

Plate 3.5 Concrete cubes casted

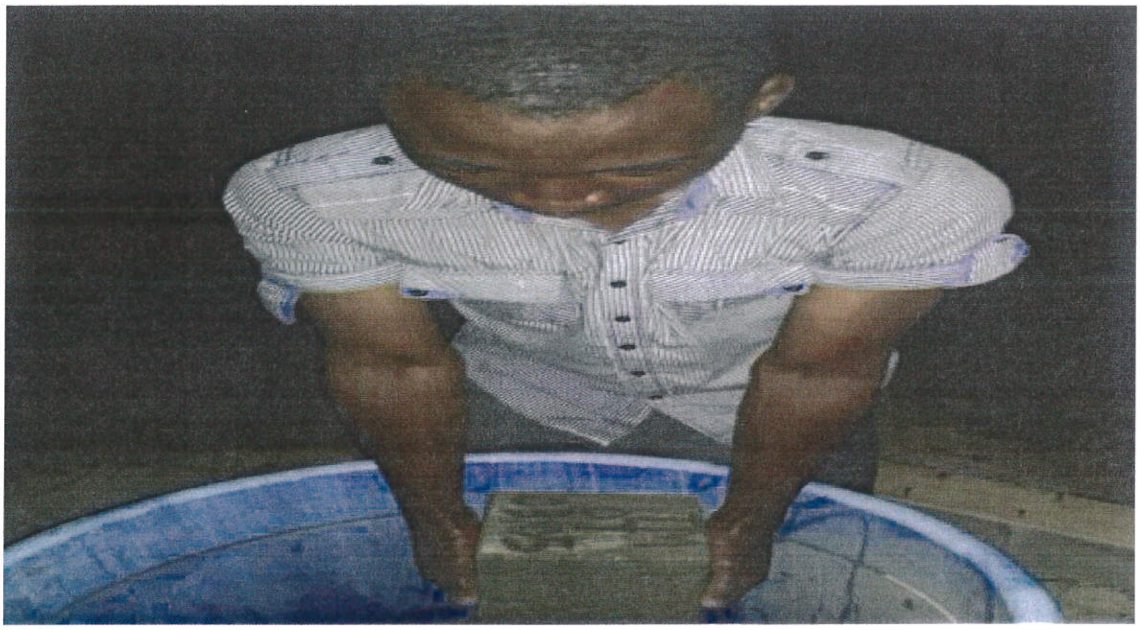

Plate 3.6 Cubes being cured 24 hours after casting

3.6. Workability (Slump test)

The slump test is a means of assessing the consistency of fresh concrete. It is used, indirectly, as a means of checking that the correct amount of water has been added to the mix. The test was carried out in accordance with BS EN 12350-2. The steel slump cone was placed on a solid, impermeable, level base and filled with the fresh concrete in three equal layers. Each layer was tamped 25 times to ensure compaction. The third layer is finished off leveled with the top of the cone. The cone was carefully lifted up, leaving a heap of concrete that settles or 'slumps' slightly. The upturned slump cone was placed on the base to act as a reference, and the difference in level between its top and the top of the concrete was measured and recorded to the nearest 5 mm to give the slump of the concrete. When the cone was removed, the slump may take one of three forms. In a true slump the concrete simply subsides, keeping more or less to shape. In a shear slump the top portion of the concrete shears off and slips sideways. Plate 3.10 shows the concrete cone after the slump test.

Plate 3.7 Slump Test

3.7. Compressive strength of concrete

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. For cube test cubical moulds of 150mm X 150 mm X 150 mm are used. For most of the works cubical moulds of size 150 mm x 150 mm x 150 mm were used for this project. These specimens were tested by compression testing machine after 7 days, 14 days and 40 days curing. Load was applied gradually at the rate of 1 40 kg/cm2 per minute till the Specimens fails. Plate 3.11 shows the compression test being carried out.

Procedure

The crushing procedure is as follows;

i The specimen were removed from water after specified curing time and wiped off of excess water from the surface.

ii The dimension of the specimen was taken to the nearest 0.2m.

iii The bearing surface of the testing machine were cleaned.

iv The specimen were placed in the machine such that the load shall be applied to the opposite side of the cube cast.

v The specimen were aligned centrally on the base plate of the machine.

vi The movable portion of the machine was rotated gently by hand so that it touches the top surface of the specimen.

vii Load was applied gradually without shock and continuously at the rate of 140kg/cm^2/minute till the specimen fails.

viii The maximum load was recorded and any unusual features in the type of failure were noted

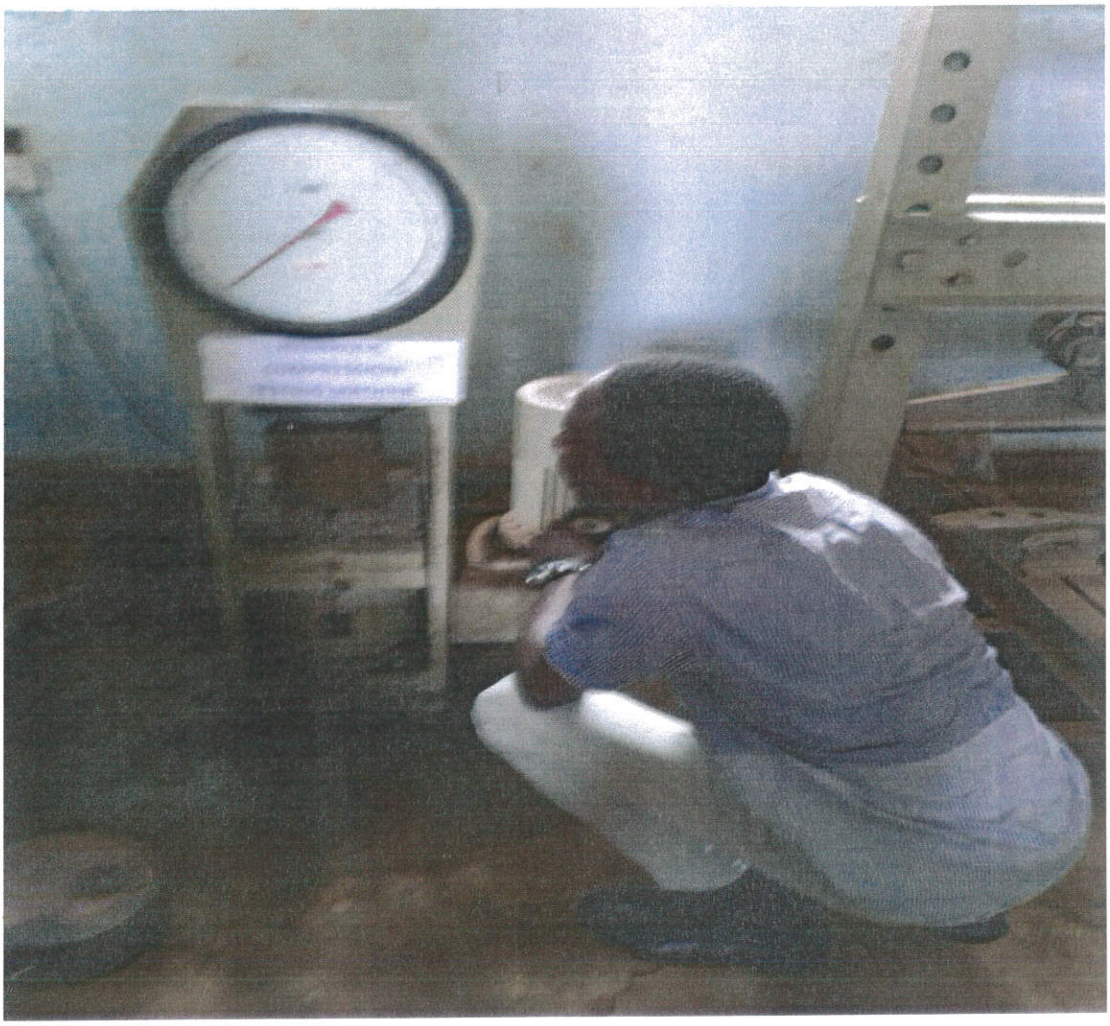

Plate 3.11. The compression testing machine.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1. Slump test

From table 4.1 below, it can be observed that the increase in partial replacement of cement at 10%, 20% and 30% Rice Husk Ash respectively in concrete leads to a gradual increase in the slump value of concrete which increases the workability of concrete. This occurs because fine particles of rice husk ash get absorbed on the oppositely charged surfaces of cement particles and prevent them from flocculation. The cement particles are thus effectively dispersed and will trap large amounts of water meaning that the system will have a reduced water requirement to achieve a given consistency.

Increase in partial replacement of Blended Rice Husk at 10%, 20% and 30% on the other hand results in a reduction in workability of concrete compared to the control mix.

Table 4.1 Effect of RHA on Workability of Concrete (Slump Test)

Percentage Replacement	**RHA (0%)**	**RHA (10%)**	**RHA (20%)**	**RHA (30%)**	**BRH (10%)**	**BRH (20%)**	**BRH (30%)**
Slump Value (mm)	50	60	68	76	32	15	5

4.2 Weight and Compressive Strength of Concrete

The 40 days strength obtained for M40 grade Control concrete is 49.07 N/mm^2. The strength results are reported in table 4.2. From the table, it is clear that as the age advances, the strength of Control concrete increases. It can also be observed from the table that as the age advances, the weight of concrete cube increases respectively.

Table 4.2 Weight and compressive strength of concrete (control mix) at 7, 14, and 40 days

Age (days)	7	14	40
Weight (N)	78.48	81.62	84.07
Compressive Strength (N/mm^2)	40.44	43.02	49.07

Table 4.3 to Table 4.6 represents the variation of compressive strength with age for M40 grade RHA concrete and BRH concrete, in each table, variation of compressive strength with age is depicted separately for each replacement level of RHA considered namely 10%, 20% and 30% and BRH namely 10%. Along with the variations shown for each replacement, for comparison, similar variations is also shown for control concrete i.e., for 0% replacement in figure 4.1. In each of these variations, it can be clearly seen that, as the age advances, the compressive strength also increases. Therefore the following observations are made;

The maximum increase in the compressive strength has occurred at 40 days with 10% replacement, whereas the compressive strength of RHA concrete is found to be decreased by 6.17% at 7 days and 1.27% at 14 days with 10% RHA replacement. Due to institutional circumstances, the concrete compressive strength test at 14 days of BRH (Table 4.5) was not conducted. Therefore, a theoretical value was calculated using interpolation. Table reveals a decrease in compressive strength in comparison to the control mix for 7 days, 14 days and 40 days having a percentage in reduction of 12.74%, 13.48% and 7.91% respectively. Although there was an increase in compressive strength of the 10% BRH over the number of days having its compressive strength at 40 days clearly higher than 20% and 30% RHA concrete mixes, with a compressive strength of 45.57 N/mm^2 it is clearly not as high as that of the control mix (50.24 N/mm^2).

During casting, the 20% and 30% partial replacement of cement with BRH failed, lacking enough cohesion to be removed from the concrete mould, the samples exhibited flakiness, softness, containing numerous voids and took a longer number of days to attain considerable hardness and dryness for demoulding and subsequently curing. Therefore they were discarded.

It can also be observed from table 4.7 that as the age advances, the weight of concrete cube increases respectively whereas there occurs a reduction in weight of concrete cube as it is being replaced partially with the various percentage of RHA and BRH. The concrete cube with the lowest weight is 30% RHA at 7 days having a weight of 63.08N.

Table 4.3 Weight and compressive strength of concrete at 10% RHA for 7, 14, and 40 days

Age (days)	7	14	40
Weight (N)	71.62	75.83	77.2
Compressive Strength (N/mm²)	38.09	42.58	50.24

Table 4.4 Weight and compressive strength of concrete at 20% RHA for 7, 14, and 40 days

Age (days)	7	14	40
Weight (N)	67	69.51	68.96
Compressive Strength (N/mm²)	33.24	35.42	40.53

Table 4.5Weight and compressive strength of concrete at 30% RHA for 7, 14, and 40 days

Age (days)	7	14	40
Weight (N)	63.08	64.45	66.71
Compressive Strength (N/mm²)	29.47	33.69	40.20

Table 4.6 Weight and compressive strength of concrete at 10% BRH for 7, 14, and 40 days

Age (days)	7	14	40
Weight (N)	68.47	69.62*	73.87
Compressive Strength (N/mm²)	35.87	37.91*	45.47

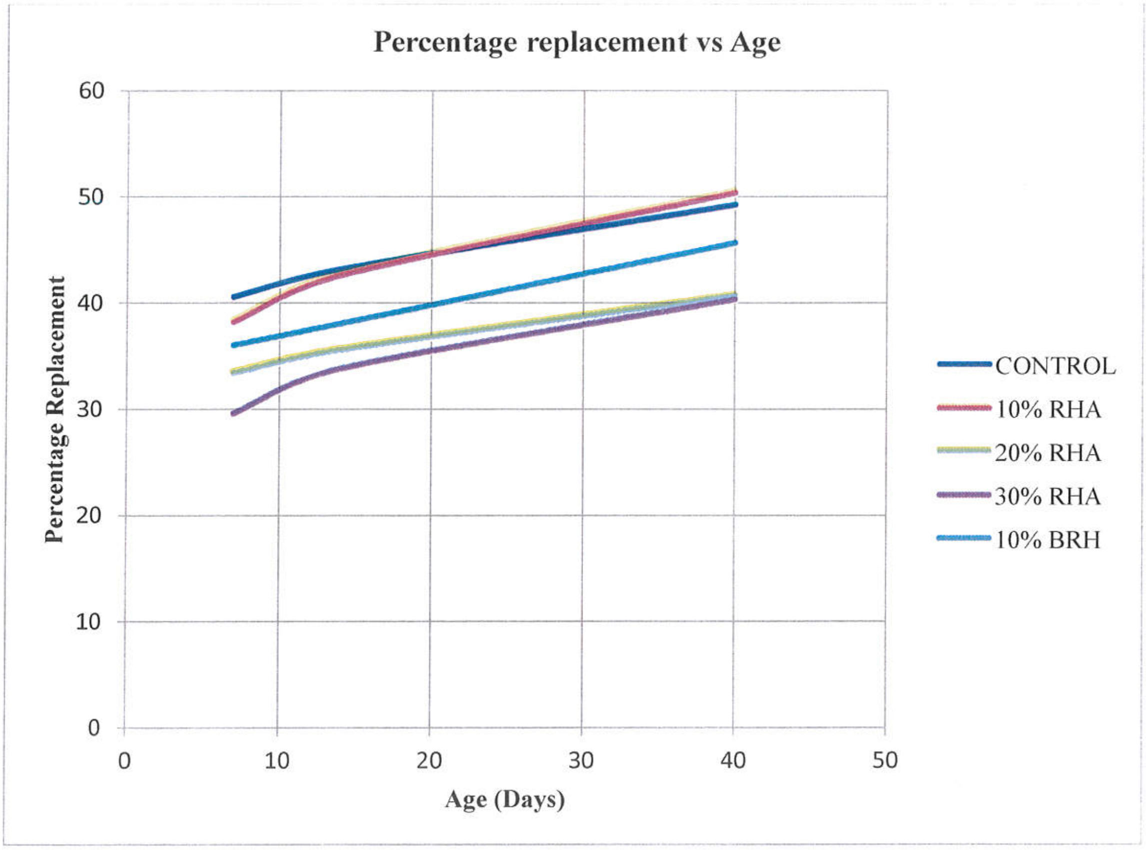

Figure 4.1. Percentage Replacement vs. Age (Compressive strength)

Table 4.7 Percentage Replacement vs. Age (Weight in N)

Percentage Replacement					
		RHA (%)			BRH (%)
Age (days)	**0**	**10**	**20**	**30**	**10**
7	78.48	71.62	67	63.08	68.47
14	81.62	75.83	69.51	64.45	69.62*
40	84.07	77.2	68.96	66.71	73.87

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Based on experiments and test results on fresh & hardened concrete the following conclusions are drawn: Due to addition of rice Husk ash concrete becomes cohesive and more plastic and thus permits easier placing and finishing of concrete. It also increases workability of concrete. Blended rice husk on the other hand becomes less cohesive. Due to addition of RHA it is observed that strength gain is slightly increasing with addition of 10% RHA in normal concrete at 7 days and at 40 days it is running parallel or more than of normal concrete. Thus 10% RHA is the optimum content for getting nearly equal strength at 40 days. Replacement of cement with Rice Husk Ash leads to increase in the compressive strength improved the workability and achieved the target strength at 10% replacement for the grade of concrete. The utilization of RHA holds promising prospects in the country because it softens the impact on the environment & capital cost of the structure. As the Rice Husk Ash is waste material, it reduces the cost of construction. It helps in reducing the pollution in environment.

5.2. Recommendation

After completing our research and testing samples of our own, it is our recommendation to use rice husk ash substitution for Ordinary Portland Cement up to 10%. This will decrease the weight of the finished project, decrease the cost, and dispose of the rice husk ash waste product. This is the best option where rice production is prevalent, including most of Nigeria precisely areas underdeveloped with higher rates of poverty. The cheaper cost of concrete can lead to more secure and longer lasting infrastructure. Also, although blended rice husk may not exhibit higher compressive strength properties than rice husk ash, it can still be used to fuel brick kilns and complement cement in building materials. The various applications of rice husk transforms it from prevalent waste product into an abundant resource and step towards national development.

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