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Potential Use of Waste Rice Husk Ash for Concrete Paving Blocks: Strength, Durability, and Run- Strength, Durability, and Run-off Properties off Properties off Properties

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Abastrct-The annual increase in OPC demand throughout the world is measured in billions of tons. Sustainable binders have the potential to reduce the rising need for cement. The use of blast furnace slag, fly ash, and silica fume, among other industrial byproducts, as a cement additive has become widespread in recent years. Silica's reactivity in rice husk ash is affected by several interconnected variables, such as incineration time and temperature. Twenty- five RHA samples were made. After extensive testing of the many variables that affect grinding efficiency, the ideal grinding setup was finally discovered. Each RHA sample was ground using the most efficient methodology. Analytical and conduct metric methods were used to ascertain the amorphous silica concentration of RHA samples, among other physical parameters. X-ray diffraction (XRD), scanning electron microscopy (SEM), and elemental analysis are only some of the experimental techniques that have confirmed the reactivity of ash. In this study, RHA concrete with a compressive strength of more than 90 MPa was produced. Increases in RHA concentration lead to notable enhancements in the performance parameters of RHA-concrete mixes, including chloride permeability, saturated water absorption, and sorptivity. The sorptivity and water absorption of RHA-blended concrete are shown to be linearly related. Comparing RHA to micro-silica in a cost-benefit analysis, we find that using RHA might lead to a 40% reduction in the price of supplementary cementitious material.

Keywords-SEM, RHA Concrete etc.

I. INTRODUCTION

Cementitious binders are increasingly important in the modern building industry. After decades in which Ordinary Portland Cement (OPC) was the go-to cement, Portland Pozzolanic Cement (PPC) has been brought back into usage as an alternative. Reasons including decreased costs, improved performance, increased durability, and environmental concerns are driving this change. Pozzolanas are defined as materials that are either siliceous or siliceous and aluminous and that have little to no cementing property on their own, but that will chemically react with calcium hydroxide in the presence of water at room temperature to form compounds with cementitious properties [ASTM C 595].

Hydraulic mortar, made from volcanic soils, was utilized as early as antiquity. Today's most popular pozzolans are fly ash and silica fumes. When compared to other biomass materials like sugarcane bagasse ash (57– 73 percent silica, SiO2), rice husk ash (RHA) has the highest concentration of biogenic silica (in excess of 95 percent) [Kapur, 1985; James and Rao, 1986; Jenkins et al., 1989; Natarajan et al., 1998; Stephens et al., 2003].

The manufacturing cost and quality of RHA are mostly determined by the incineration temperature and time. Researchers from all over have tried their hand at developing a reliable and efficient process for incorporating RHA into the concrete manufacturing process. However, the processes involved in making reactive RHA have not been studied systematically or in depth. Both economically and technologically, the best manufacturing process is crucial.

II. THE FIELD OF STUDY AT HAND

- Burning locally available rice husk at different temperatures and for different amounts of time under regulated conditions is required to produce ash.
- Ashes must be tested for their physical, chemical, and microstructural qualities to determine their quality.
- There has to be research on how these ashes influence the hardening of cement mortar.

- The best circumstances for creating reactive RHA would be determined by factors such as the amount of energy used in the production process, the qualities of RHA (such as its physical, chemical, and microscopic states), and the results of strength testing performed on cement-RHA mortar specimens.
- It is necessary to investigate the impact of RHA (manufactured under ideal circumstances) on the durability of concrete mixes that use only a portion of OPC as a substitute. Besides strength,it is important to investigate other performance aspects of concrete made with rice husk ash, such as its chloride permeability, water absorption, and sorptivity.

III. RICE HUSK– A REVIEW

1. Introduction

This chapter has covered the characteristics and composition of rice husk, as well as the different industrial Applications Of Rice Husk Ash.

2. Rice Cultivating

The cultivation of paddy rice (Oryza sativa) takes up around 1 percent of the Earth's area, and it is farmed on every continent except Antarctica. Rice is grown on more land and produces more rice than wheat does, although wheat is the staple grain for more than half the world's population. Nearly 650 million tons of paddy are harvested each year across the world [www.mapsoftheworld.com]. Asia is the world's largest producer of rice since it is the only major food crop that can be cultivated throughout the wet season in the tropics. Table 2.1 shows that Asia produces more than 90% of the world's rice.

3. Rice Husk Characteristics

One material with the potential for value addition is rice husk. Both the raw and burned versions of rice husk have a wide variety of applications. A minor percentage of the husk is employed as fuel for boilers, power production, bulking agents for composting animal manure, etc. [Bronzeoak, 2003; Asavapisit and Ruengrit, 2005], while the vast majority is either burned or discarded as trash in open areas. Rice husk is made up of dentate, rectangular pieces that are mostly made of silica and have a thick cuticle and surface hairs for protection. There is little silica in the dermis or the inner epidermis [Bronzeoak, 2003]. The existence of amorphous silica in the rice husk was verified to be localized on its exterior by Jauberthie et al. (2000). Similar to many other common organic fibers, rice husk has a chemical makeup of 40–50% cellulose, 25–30% lignin, 15-20% ash, and 8–15% moisture [Hwang and Chandra, 1997]. Most volatile components slowly evaporate away during the burning process, leaving behind silicates.

4. Rice Husk Thermal Decomposition

Carbonization and decarbonation are two different steps in the decay of rice husks. Carbonization occurs when the volatile components of rice husk are subjected to temperatures higher than 300 degrees Celsius, resulting in the production of gaseous fuel and tar. As shown in Fig. 2.2 [Maeda et al., 2001], decarbonation involves the burning of the fixed carbon in the rice husk char at higher temperatures in the presence of oxygen. RHA has a melting point of about 1440 degrees Celsius, or the same as silica [Bronzeoak, 2003].

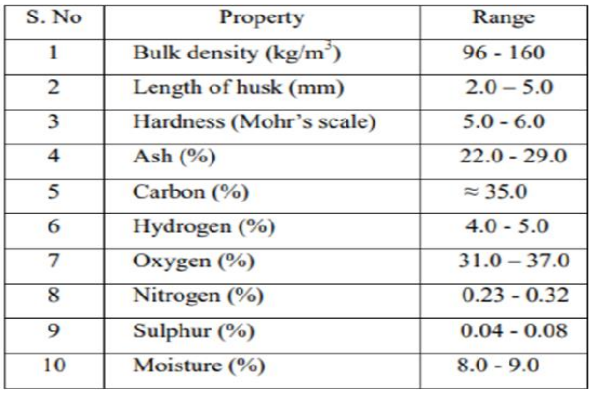
5. Silica Formats In Rha

Silica makes up 87–97 percent of rice husk ash, with certain alkalis and trace minerals also present. Because of the differences in characteristics between crystalline and amorphous silica, it is crucial to manufacture ash that meets the requirements of its intended application. The silica tetrahedra that make up amorphous silica are often dispersed randomly in a three-dimensional network devoid of regular lattice structures (Fig. 2.3). As a result of the disorganized layout, the structure is porous and contains electrically non-neutral regions with a significant specific surface area. Since a sizable region is made accessible for a reaction to take place, the reactivity is enhanced [Shomglin et al., 2001].

6. Uses For Rice Husk Ash

RHA has several uses in sectors that rely on silicon. There has been much study into the potential benefits of using RHA as a mineral additive in concrete production. Amorphous RHA can be utilized as an additive in high-strength and high- performance concrete and as a partial replacement for Portland cement. We take a closer look at how RHA is being put to use in the building sector, in particular in the manufacturing of concrete. The following are a few of its many additional applications: Crystalline RHA is in high demand in the steel and ceramic sectors and in the production of refractory bricks [Prasad et al., 2000; Bronzeoak, 2003] because of its refractory qualities. Basha et al. (2005) looked at the feasibility of using a mixture of RHA and cement as a stabilizing agent to enhance the qualities of residual soil.

Table 2.2: Typical husk analysis [Bronzeoak, 2003]



S. No	Property	Range
1	Bulk density (kg/m^3)	96 - 160
2	Length of husk (mm)	2.0 – 5.0
3	Hardness (Mohr's scale)	5.0 - 6.0
4	Ash (%)	22.0 - 29.0
5	Carbon (%)	≈ 35.0
6	Hydrogen (%)	4.0 - 5.0
7	Oxygen (%)	31.0 – 37.0
8	Nitrogen (%)	0.23 - 0.32
9	Sulphur (%)	0.04 - 0.08
10	Moisture (%)	8.0 - 9.0

IV. PRODUCTION METHODOLOGIES AND PROPERTIES OF RHA-A REVIEW

1. Introduction

Ash may be produced using a variety of methods, from traditional open- heap burning to more advanced incinerators like fluidized beds. Several techniques for determining the amount of amorphous silica present in rice husk ash (RHA) have been explored, and the literature on these techniques has been critically reviewed. The physical, chemical, and microstructural characteristics of RHA are discussed, along with a summary of previous researchers' work on these topics.

2. Technologies For The Manufacture Of Ash

Alkaline extraction and heat treatment in various thermal treatment technologies were found in a technology screening to be viable means of extracting amorphous silica from rice husk.

3. The Use of Alkaline Extraction:

In this procedure, rice husk ash was combined with NaOH and then heated in a covered Erlenmeyer flask for 1 hour while being continuously stirred. The carbon residue was subsequently filtered out of Solution 15 using ash-free filter paper. The sodium silicate filtrate was brought down to room temperature, then gently titrated with acid (either hydrochloric or sulfuric acid) while being stirred until the pH reached 7. After 18 hours of aging at ambient temperature, the solution had transformed into silica gel [Kamath and Proctor, 1998].

4. Thermal Methods of Treatment:

The production of amorphous silica from rice husk has traditionally relied on thermal treatment methods such as the fluidized bed combustor, industrial furnace, and rotary kiln. The combustion of rice husk in a fluidized bed combustor is another option for making pozzolanic RHA. It refers to a variety of boiler configurations in which fuel is burned beneath a bed of inert material that is kept "fluid" by a supply of rising air. It may be necessary to add inert material to the bed to guarantee there is enough inventory for steady fluidization if the fuel has a 16 ash percentage. The technique involved the generation of steam or electricity from the heat generated by the burning of rice husks. Fluidized bed combustors have certain drawbacks, including the following:

1. Fluidizing a bed requires a relatively significant pressure drop.
2. The flue gas contains a high dust burden; etc. The rotating kiln is an improvement on the muffle furnace for mixing the rice husk to facilitate the production of amorphous silica from rice husk.

4. Techniques For Making Ash:

Controlled burning of rice husk at temperatures below 700℃ has been reported to produce amorphous ash, whereas burning at temperatures above 800℃ has produced crystalline ash. Crystalline ash may occur at temperatures as low as 350 °C, according to Bui (2001), who also stated that 15 hours of exposure was all it took to produce it. James and Rao (1986) conducted an in-depth investigation of the processing and responsiveness of RHA. Based on their research into the pozzolanicity of RHA, Khalaf and Yousif (1984) stated that the 500°C–2 hours combination was the most cost-effective burning condition for the synthesis of RHA. The sensitivity of RHA's reactivity to lime formation temperature, which can range from 400°C to 900°C for incineration times between one and thirty hours, was investigated by James and Rao (1986).

Effect of Geographical Locations on RHA Quality

RHA is mostly produced in Southeast Asian countries, which contribute over 25 million tons to the global total. Some research [Chandrasekar et al., 2003; Bronzeoak, 2003] has revealed that the soil chemistry, paddy variety, and weather conditions all affect the physical and chemical qualities of ash. Fertilizers used in rice production have been demonstrated to cause variations [Maeda et al., 2001; Chandrasekar et al., 2003]. However, it was shown that there is little variation in the chemical makeup of RHA among regions (Table 3.2).

Amorphous Silica Detection In Rha

The quality, structure, and surface appearance of silica produced from RHA vary depending on the conditions in which it is made. Therefore, determining the amount of amorphous silica present in RHA samples is crucial for finding the optimal manufacturing conditions.

Methods of Analysis

The amount of amorphous silica present in RHA may be determined using one of many current analytical procedures. Mehta (1973) suggested one such method, in which the amorphousness of silica is assessed by determining how much silica can be extracted from a sample in three minutes using an excess of boiling 0.5M sodium hydroxide. James and Rao (1986) made an effort to put a number on RHA's sensitivity to lime. RHA was weighed up to 0.3 g and then divided across 100 ml beakers at 0.025 g intervals. Each beaker had 50 ml of a 21.5 molar calcium hydroxide solution added to it, and the mixture was shielded from exposure to carbon dioxide.

Methods Employing Instruments

The amorphous or crystalline condition of silica in RHA may be determined using both analytical procedures and instrumental approaches. The crystalline component of a material may be investigated by X-ray diffraction. A strong method for characterizing amorphous silica, nuclear magnetic resonance (NMR), investigates the local structure of a silicon atom. NMR resonances are narrow and characteristic of crystalline samples due to their welldefined bond angles [Pettifer et al., 1988], whereas those of amorphous samples are wide and indicative of their bond angle dispersion. 22 While NMR has seen extensive usage in the study of silicates and zeolites, its use in the study of pozzolanas, and particularly RHA, has lagged. To measure pozzolanicity, Luxan (1989) proposed using electrical conductivity. Before and after adding 5 grams of powdered pozzolanic material to a 200-ml saturated calcium hydroxide solution at 40°C, the electric conductivity of the solution is measured. After 2 minutes, pozzolanicity may be inferred from the electric conductivity change. Pozzolanicity is considered good when the conductivity value is greater than 1.2, bad when it is less than 0.4, and variable when it is between 0.4 and 1.2. After dissolving 200 mg of pozzolana in a 0.7% hydrofluoric acid solution for 30 minutes, Surana and Joshi (1990) developed a straightforward conduct metric method for gauging the activity of pozzolanic materials. There is a one-to-one relationship between the silica content and the specific conductivity. However, with this technique, results may be significantly impacted by pozzolana elements other than reactive silica.

Different Physical Traits Of Rha

Scientists have spent years attempting to link the physical qualities of pozzolanas like fly ash with their activity. These parameters include specific gravity, fineness, and particle size dispersion. However, there has been no dedicated study of RHA that links its physical properties to its activity.

The Size Distribution of Particles

RHA is a porous substance with particles of varying sizes and shapes. Mehta (1979), Hwang and Chandra (1997), and Bronzeoak (2003) have all suggested that certain particles may have a spherical shape. A median particle size of roughly 8 m is necessary to obtain a pozzolanic activity index of 100%, as determined by Bouzouba and Fournier (2001). Based on their research, Nehdi et al. (2003) concluded that RHA with particle sizes finer than cement should be expected to play not only a pozzolanic role but also a micro filler effect to enhance the particle packing density of concrete, thereby improving the material's properties. Particles less than 45 m in size can often participate in the pozzolanic process. Fineness.

Although Nehdi et al. (2003) found that unground RHA increases strength at older ages, the need for a superplasticizer to provide the necessary workability makes its usage costly to justify. The fineness of the RHA particles generated is significantly influenced by production temperature and incineration time. The surface area of RHA burned at 500–600 °C for 1 minute without crystallization was as high as 122 m2 /g 25, as reported by Hwang and Chandra (1997). When something is burned over an extended period of time, its surface area decreases because the cells collapse and the tiny holes converge. They came to the following conclusions.

1.Incinerating temperature has a much larger effect on specific surface area than incinerating time does;
(ii) a furnace temperature of less than 550°C is required to produce RHA with a specific surface area greater than 50 m2/g and a loss on ignition of less than 3 percent; and
(iii) incinerating time must be sufficient to completely combust fixed carbon in the RHA.

4.5.3Density and Specific Gravity:

RHA's bulk density ranges from 112 to 202 kg/m3 [Nehdi et al., 2003; Bui et al., 2005; Ganesan et al., 2008; Zhang et al., 1996], while its specific gravity stays within a limited range of 2.02 to 2.16. Although the bulk density of RHA is a unique property in and of itself, it does shed some insight on the type of ash being generated.

4.6. Ignition Loss:

RHA typically has some unburned components and some inert husk components. Carbon is the most abundant element in the unburned portion. The presence of carbonates coupled water in remaining clay minerals, and burning of free carbon all contribute to the weight loss of ash burned at temperatures below 1000°C. RHA's carbon content changes as a function of its manufacturing environment. Carbon concentration peaks at around 7% in well-made RHA, according to some sources [Bronzeoak, 2003].

4.6.1 The Makeup of Oxides

Since 1938 [Chandrasekhar et al., 2003], it has been understood that rice husk contains silica. RHA is mostly composed of silica (87-97%), with trace amounts of alkalis and other elements. Table 3.2 details the chemical make-up of RHA samples collected from various locales. They found that ash particles are permeable and round up to 500 degrees Celsius. At 600°C, the ash was partially crystallized, but at 900°C, it was the defining characteristic. The SEM micrographs also showed that when the combustion temperature rose, the globular shape grew in size from 5 to 50 m. The smallest particles and pores measured up to 1 micrometer in size. At higher combustion temperatures, agglomerates seemed to compress further.

In addition, the transition between the amorphous and crystalline states may have been shown around 600°C by the appearance of tiny porous crystalline grains smaller than 1m. The temperature was 900 degrees Celsius. Hwang and Chandra (1997) used microscopy to investigate, and they found that crystals generated at 700°C and 800°C were of similar type; however, some crystals converted to a coral-shaped arrangement, presumably as a result of temperature impacts. Coral-shaped crystals formed at a higher rate between 900 and 1000 degrees Celsius. At 1000 degrees Celsius, the crystals still had the characteristic coral form, but they were much more finely divided and melted.

V. EXPERIMENTATION AND METHODOLOGY FOR THE PRODUCTION OF REACTIVE RHA

The procedures for creating reactive rice husk ash are described. Ash was produced using a variety of experimental methods and processes, and its reactivity was evaluated using a variety of analytical techniques. Optimal conditions that exist in the manufacturing domain of reactive RHA have also been programmed into the experiments. The majority of the testing procedures used here are in accordance with BIS standards. When BIS procedures couldn't be used, however, other relevant international standards were used instead. All tests were done with a minimum of three replicates, and further replicates were performed if experimental results deviated by more than 15% from the mean.

1. Tests On Concrete

Several studies [Ganesan et al., 2008; Nehdi et al., 2003; Hwang and Chandra, 1997] detail the positive effects of RHA-blend concrete on construction performance. Permeability features of RHA-mixed concrete are poorly understood, however. Because it regulates the passage of water during wetting and drying as well as the pace at which moisture containing hostile chemicals may penetrate the concrete, permeability plays a crucial role in durability. Therefore, in this study, we test for a number of permeability properties, including chloride permeability, water absorption, and sorptivity. Reference was made to the strength, performance qualities of hardened concrete, and cost to determine that a replacement rate of 155 percent was appropriate.

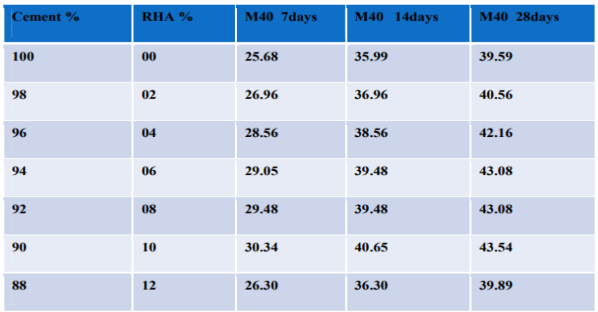
Proper Ratio For Concrete

The impact of RHA on a range of concrete performance indicators, from 0% to 30% replacement, was studied. The research also took into account the mix proportions used in the strength studies (Table 6.4). That is, four different types of concrete, labeled C550, C500, C450, and C350, have been taken into consideration.

Specimen Casting

Each mixture's dosage of super plasticizer was adjusted to produce a slump of 75–100 mm. The specimens were cast and cured according to subsection 6.4.3. In order to investigate the properties of RHA concrete, 320 samples were made: 224 cylinders (100 mm in diameter and 50 mm in depth) for the rapid chloride permeability and sorptivity test, and 96 cubes (also 100 mm in size) for the water absorption test. Wet gunny bags were placed over the molds immediately after casting the specimens and left there for a full day. After being removed from the molds, the samples were allowed to cure in room-temperature water until the day of testing. Absorption of Water Test the percentage of water absorbed is a measurement of the pore volume or porosity filled by water in a saturated condition in concrete that has hardened. A material's sorptivity reflects the capillary forces produced by its pore structure, which attract fluids into the material's body [Hall, 1989]. Here's a quick rundown of the steps involved: For four days at 50 degrees Celsius, followed by three days of cooling in a sealed container, concrete samples were preconditioned for testing. Transparent epoxy glue was applied to the concrete samples' sidewalls to channel the flow. The starting mass was measured, and the specimen was submerged in water to a depth of 5 mm for 10 minutes.

VI. TEST RESULTS



Cement %	RHA %	M40 7days	M40 14days	M40 28days
100	00	25.68	35.99	39.59
98	02	26.96	36.96	40.56
96	04	28.56	38.56	42.16
94	06	29.05	39.48	43.08
92	08	29.48	39.48	43.08
90	10	30.34	40.65	43.54
88	12	26.30	36.30	39.89

VII. CONCLUSION

Cement in paving blocks was partially replaced by six percentages of waste RHA: 0%, 2%, 4%, 6%, 8%, 10% and 12% (by weight). At 10% waste RHA, paving block structure became denser than the conventional block, and 28-day compressive strength was improved by 9.6%. Man-made pozzolanas are often waste products from other industries. The raw ingredients and production circumstances utilized to create these pozzolans determine their final characteristics. Since rice husk is a by-product of the agricultural sector, it stands to reason that the quality of such by-products may fluctuate if the raw materials used in their production were to alter. Mehta received a patent in 1973 for the manufacture of RHA suitable for use as pozzolana.

Since then, there have been major developments in the research on the behavior of RHA-blended cement concrete and the usage of RHA as a pozzolana. Several different sectors in nations, including the United States, Brazil, China, Thailand, etc., generate RHA for sale. A few companies in India also produce and sell RHA on the open market. However, for economic reasons, the production method must remain secret. Many researchers have employed prefabricated RHA or have manufactured their own RHA according to a predetermined manufacturing approach in order to conduct studies involving RHA as a pozzolana. The current study at Holy Mary College aimed to determine the optimal combustion temperature and time for RHA so as to maximize the material's pozzolanicity. In addition, the most efficient concrete manufacturing settings and RHA doses were sought. The results of this investigation are quite promising, and some of the discoveries may represent important advances in concrete technology.

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