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Use of Rice Husk Ash in Concrete

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A PROJECT ON
USE OF RICE HUSK ASH IN CONCRETE



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ACADEMIC YEAR: 2014-2015

UNDER GUIDANCE OF
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CERTIFICATE

This is to certify that project report submitted by the students of final year Diploma in Civil Engineering (2014-15) on “*Use of Rice Husk Ash in Concrete*” have satisfactory completed the requirements of project.

And I have instructed and guided them for the said work from time to time and I have found them satisfactory progressive.

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SUBMISSION

We, the students of final year of the course Diploma in Civil Engineering humbly submit the project that we have completed from time to time. I have completed the project work by my own skills as per guidance of our guide

And the teacher has approved that the following students were associated for this work, however quantum of my contribution.

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SIGNATURE OF THE STUDENTS

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ABSTRACT

Over 5% of global CO₂ emissions can be attributed to Portland cement production. Demand for cement continues to grow. It increases in the cost of conventional building materials and to provide a sustainable growth, the entire construction industry is in search of a suitable and effective waste product that would considerably minimize the use of cement and ultimately reduce the construction cost. For this objective, the use of industrial waste products and agricultural byproducts are very constructive. These industrial wastes and agricultural byproducts such as Fly Ash, Rice Husk Ash, Silica Fume, and Slag etc. can be used as cementing materials because of their pozzolonic behavior, which otherwise require large tracts of lands for dumping. Large amounts of wastes obtained as byproducts from many of the industries can be the main sources of such alternate materials. The world rice harvest is estimated as 738.1 million tons per year and India is second largest producer of rice in the world with annual production of 152.6 million tons per year.

Thus the concrete industry offers an ideal method to integrate and utilize a number of waste materials, which are socially acceptable, easily available, and economically within the buying powers of an ordinary man. Presence of such materials in cement concrete not only reduces the carbon dioxide emission, but also Imparts significant improvement in workability and durability.

INTRODUCTION

1.1GLOBAL URBANIZATION:-

The world at the end of the 20th century that has just been left behind was very different to the world that its people inherited at the beginning of that century. The latter half of the last century saw unprecedented technological changes and innovations in science and engineering in the field of communications, medicine, transportation and information technology, and in the wide range and use of materials. The construction industry has been no exception to these changes when one looks at the exciting achievements in the design and construction of buildings, bridges, offshore structures, dams, and monuments, such as the Channel Tunnel and the Millennium Wheel.

In global terms, the social and societal transformations that have occurred can be categorized in terms of technological revolutions, population growth, worldwide urbanization, and uncontrolled pollution and creation of waste. But perhaps overriding all these factors is globalization.

The unprecedented changes that have occurred in the world and society during the latter half of the last century have placed almost insatiable demands on the construction industry in terms of the world's material and energy resources. Continued population growth and evolutionary industrialization have resulted in an endless stream of global urbanization. It took the world population until the year 1804 to reach the first one billion; yet the increase from 5 to 6 billion has taken just 12 years.

This explosion into an urban way of life will continue to demand enormous resources and supply of construction materials required to build the infrastructure - such as housing, transportation, education, power, water supply and sanitation utilities - the basic facilities needed to support life in these mega cities and big cities.

The massive and wasteful consumption of a disproportionate share of the earth's material and energy resources by the industrialized nations of the world has resulted in a massive increase in the emission of greenhouse gases. In 1960, CO₂ emission was about 10 billion tones. In 1995, this was about 23 billion tones excluding those from deforestation and fires. About 4% of the world population produces around 25% of the

world's CO₂ emission! Some 60% reduction in CO₂ emission is required to stabilize the earth's eco system and climatic changes. The Kyoto agreement in 1997 was to reduce the CO₂ emission from the developed world by 5% by 2012! The Portland cement industry accounts for some 5 to 7% of the total global emission of CO₂. The direct and unmistakable consequence of the emission of greenhouse gases is Global Warming.

Ordinary Portland cement (OPC) consists of 95% clinker and 5% gypsum. The clinker is produced from crushing limestone together with other minerals and then heating them at high temperatures (900-1,450°C). During finishing, the gypsum is added to the clinker as it is ground to a small particle size (typically 10-15 microns). The clinker is the most energy and emissions intensive aspect of cement production, thus it is known as “the clinker factor”; for example, OPC has a clinker factor of 0.95. The global warming potential (GWP) of the cement is reduced by reducing the clinker factor – this is achieved in blended cements by inter-grinding pozzolans or slags with the clinker during finishing. Blended cements are far more popular in Europe, than in North America, the U.K. and most of Asia.

According to an independent evaluation of the industry in 2006, in the last 25 years there have been 30% reductions in CO₂ emissions, by some companies. These are attributed mainly to the adoption of more fuel-efficient kiln processes. The most potential for further improvement is in the increased utilization of renewable alternative fuels and the production of blended cements with mineral additions substituting clinker.

Global development and the real estate boom of the past two decades have sharply affected the demand for basic materials, especially cement. **Figure 1** also shows an increased need for steel. The ominous cement emissions statistics often raise the following question: “since steel is totally recyclable, why not just use that?” For certain a structure, steel is the appropriate choice; however there are many project-specific factors to consider before determining the right and most sustainable material. Structural steel (usually 90% recycled) has an embodied energy content of 27,500,000 BTUs/ton, (compared to 817,600 BTUs/ton for typical OPC concrete) – so by energy measures alone using steel is far from a sustainable solution. Furthermore, because cement has a

low material cost/labor intensity ratio, it will likely remain the building material of choice for most of the developing world. This is a major reason why concrete is important.

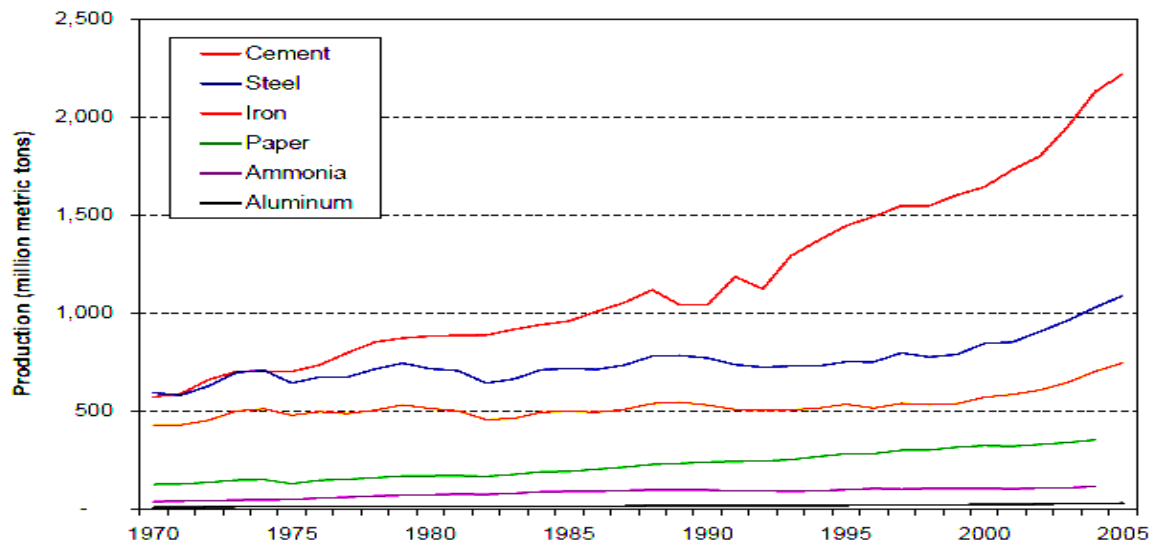


Figure 1: Growth in demand for Primary materials; Source: US Geological Survey

1.2 CONCRETE & ENVIRONMENT:-

How does concrete fit into this complex world scenario of the construction industry? The answers are simple but wide-ranging. Whatever be its limitations, concrete as a construction material is still rightly perceived and identified as the provider of a nation's infrastructure and indirectly, to its economic progress and stability, and indeed, to the quality of life. It is so easily and readily prepared and fabricated into all sorts of conceivable shapes and structural systems in the realms of infrastructure, habitation, transportation, work and play. Its great simplicity lies in that its constituents are most readily available anywhere in the world; the great beauty of concrete, and probably the major cause of its poor performance, on the other hand, is the fact that both the choice of the constituents, and the proportioning of its constituents are entirely in the hands of the engineer and the technologist. The most outstanding quality of the material is its inherent alkalinity, providing a passivating mechanism and a safe, non-corroding environment for the steel reinforcement embedded in it. Long experience and a good understanding of its

material properties have confirmed this view, and shown us that concrete can be a reliable and durable construction material when it is built in sheltered conditions, or not exposed to aggressive environments or agents. Indeed, there is considerable evidence that even when exposed to moderately aggressive environments, concrete can be designed to give long trouble-free service life provided care and control are exercised at every stage of its production and fabrication, and this is followed by well-planned inspection and maintenance schemes.

In spite of this excellent known performance of concrete in normal environments, there are two aspects of the material that have tarnished its image. The first relates to the environmental impacts of cement and concrete, and the second, to the durability of the material. Engineers cannot afford to ignore the impact of construction technology on our surroundings - and this applies to our environment at a regional, national and global scale. The construction industry has a direct and visible influence on world resources, energy consumption, and on carbon dioxide emissions. Compared to metals, glass and polymers, concrete has an excellent ecological profile.

For a given engineering property such as strength, elastic modulus or durability, concrete production consumes least amount of materials and energy, produces the least amount of harmful byproducts, and causes the least damage to the environment. In spite of this, we have to accept that Portland cement is both resource and energy - intensive. Much more importantly, every tone of cement releases 1.0 to 1.2 tons of CO₂ into the environment by the time the material is put in place. In the world we live in, the use of resources and energy, and the degree of atmospheric pollution that it inflicts are most important.

The experience that even when specific building code requirements of durability in terms of concrete cover and concrete quality are achieved in practice, there is an unacceptably high risk of premature corrosion deterioration of concrete structures exposed to aggressive salt-laden environments, directly points to the fact that Portland Cement concretes are not totally resistant to penetration by aggressive ions, even when the water cementitious materials (w/cm) ratio is as low as 0.40. The strong implication here is that with current design codes, premature deterioration due to steel corrosion is likely to

continue. There is thus a need for a fundamental change in thinking about concrete and concrete quality made with Portland cement.

Significant changes have been occurred in the chemical composition of Portland Cements during the last four to five decades. The two major changes in cement composition and their implications on engineering and durability properties of the resulting concrete can be identified as:

- i) A significant increase in the C3S/C2S ratio from about 1.2 to 3.0 resulting in higher strengths at early ages with a lower proportion of strength developed after 28 days. From a design point of view, this implies that structural design strengths can be achieved with lower cement contents and higher water/cement ratios.
- ii) A direct result of the changes in this chemical composition of Portland cement is an increase in the heat of hydration evolved, and more importantly, in the evolution of heat at early ages. It is estimated that the average increase in peak temperature is about 17%, and this peak temperature is reached in less than half the time the high strength may appear to be attractive at first sight, but may give misleading ideas of durability.

<u>TABLE:1 CEMENT PRODUCED AND CO₂ EMITTED</u>							
2005 Production / Emission (M Tones)						2050 Projected (BAU)	2050 Projected (BAP)
	USA	Canada	India	China	Global	Global	Global
Cement Produced	121	11.2	130	1064	2300	5500	5500
Total CO₂	109	10	117	958	2700	4950	4400

1.3 MODIFIED BINDERS:-

Extensive research has now established, beyond a shadow of doubt that the most direct, technically sound and economically attractive solution to the problems of reinforced concrete durability lies in the incorporation of finely divided siliceous materials in concrete. The fact that these replacement materials or supplementary cementing materials as they are often known and described, such as ***Fly Ash, Ground Granulated Blast Furnace Slag (GGBS), Silica Fume & Rice Husk Ash (RHA)*** are all either pozzolanic or cementitious make them ideal companions to Portland Cement. ***Every tone of cement clinker requires about 4000 to 7500 MJ total energy for production while slag requires only 700 to 1000 MJ/tone, and PFA about 150 to 400 MJ/tone.***

It is now well-established that the incorporation of industrial byproducts such as PFA, slag and Rice Husk Ash in concrete can significantly enhance its basic properties in both the fresh and hardened states. Apart from enhancing the rheological properties and controlling bleeding of fresh concrete, these materials greatly improve the durability of concrete through control of high thermal gradients, pore refinement, depletion of cement alkalis, resistance to chloride and Sulphate penetration and continued microstructural development through long-term hydration and pozzolanic reactions. Further, concrete can provide, through chemical binding, a safe haven for many of the toxic elements present in industrial wastes; and there are strong indications that these mineral admixtures can also reduce the severity of concrete deterioration problems arising from chemical phenomena such as alkali silica reaction, delayed ettringite formation and thaumasite formation.

A critical evaluation of the world scenario described above emphasizes the complex but close interrelationship between three seemingly unrelated but gigantic problems that confront the construction industry, namely - The insatiable infrastructure needs of a rapidly growing and urbanizing world coupled with the desire for a better quality of life of nations suffering from a lack of availability and accessibility to world resources, global warming, and the consequent destruction of infrastructure through natural disasters. - The need to achieve a balance between economic development and protection of environment - The crises in the area of materials and durability.

1.4 21ST CENTURY CONCRETE CONSTRUCTION:-

Bearing in mind the technical advantages of incorporating PFA, slag, SF and other industrial pozzolanic byproducts in concrete, and the fact that concrete with these materials provides the best economic and technological solution to waste handling and disposal in a way to cause the least harm to environment. Indeed a stage has now been reached where the use of PC alone as the binder in the concrete system would need to be justified before such a material can be accepted for construction. Viewed in this way, the 21st century concrete will be seen as a provider for mankind with a construction material requiring the least consumption of energy and raw material resources, and reduced environmental pollution through reduced carbon dioxide emissions.

Enhancement of the durability of infrastructure construction and stopping of the desecration of the environment - the essential basis for quality of life - should thus be the criteria for selection of material constituents for the 21st Century Concrete. This report will introduce and explore the usage Rice Husk Ash (RHA) as a replacement along with cement. Fly ash has been thoroughly studied and used for several decades, yet current usage is far below its potential. The benefits of rice husk ash (also known as rice hull ash) have been documented since the 1980's, yet it remains barely available in the INDIA. The addition of recovered ultra-fines (such as mineral flours) to concrete has gotten relatively little attention, especially in the INDIA.

1.5 SCOPE OF THE PROJECT:-

The Experimental investigation is planned as under:

- 1) To obtain Mix proportions of Control concrete by Department of Environment (DOE) method.
- 2) To conduct Compression test on RHA and Control concrete on standard IS specimen size 150 x 150 x 150 mm.
- 3) To conduct Slump test on RHA Concrete and Control concrete.

1.6 OBJECTIVE OF THE PROJECT:-

The aim of the present investigation is:-

- 1) To study compressive strength properties of Rice husk ash concrete with age in comparison to Control concrete.
- 2) To study the relative strength development with age of Rice husk ash concrete with Control concrete of same grade.

LITERATURE ON
RICE HUSK ASH

2.1 GENERAL:-

Rice milling generates a byproduct known 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 firing process, is known as ***Rice Husk Ash (RHA)***.

As per study by Houston, D. F. (1972) RHA produced by burning rice husk between 600 and 700°C temperatures for 2 hours, contains 90-95% SiO₂, 1-3% K₂O and < 5% unburnt carbon. Under controlled burning condition in industrial furnace, conducted by Mehta, P. K. (1992), RHA contains silica in amorphous and highly cellular form, with 50-1000 m²/g surface area. So use of RHA with cement improves workability and stability, reduces heat evolution, thermal cracking and plastic shrinkage. This increases strength development, impermeability and durability by strengthening transition zone, modifying the pore-structure, blocking the large voids in the hydrated cement paste through pozzolanic reaction. RHA minimizes alkali-aggregate reaction, reduces expansion, refines pore structure and hinders diffusion of alkali ions to the surface of aggregate by micro porous structure.

The particle size of the cement is about 35 microns. There may be formation of void in the concrete mixes, if compaction is not done properly. This reduces the strength and quality of the concrete. Grinded Rice Husk Ash (RHA) is 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.

More recently, studies have been carried out to purify it and use it in place of silica in a range of industrial uses, including silicon chip manufacture. RHA is a general term describing all types of ash produced from burning rice husks. In practice, the type of ash varies considerably according to the burning technique. Two forms predominate in combustion and gasification. The silica in the ash undergoes structural transformations depending on the temperature regime it undergoes during combustion. At 550°C – 800°C

amorphous silica is formed and at greater temperatures, crystalline silica is formed. These types of silica have different properties and it is important to produce ash of the correct specification for the particular end use. Currently, nothing is available that even approaches a standardized guideline for the proportioning of RHA in concrete mixes. Designers should bear in mind that due to RHA's large surface area, it typically causes a slight increase in water demand.

2.1.1 HYDRATION MECHANISM OF CONCRETE WITH RHA:-

Portland cement contains 60 to 65% CaO and, upon hydration, a considerable portion of lime is released as free Ca(OH)_2 , which is primarily responsible for the poor performance of Portland cement concretes in acidic environments. Silica present in the RHA combines with the calcium hydroxide and results excellent resistance of the material to acidic environments. RHA replacing Portland cement resists chloride penetration, improves capillary suction and accelerated chloride diffusivity.

Pozzolanic reaction of RHA consumes Ca(OH)_2 present in a hydrated Portland cement paste, reduces susceptible to acid attack and improves resistance to chloride penetration. This reduces large pores and porosity resulting very low permeability. The pozzolanic and cementitious reaction associated with RHA reduces the free lime present in the cement paste, decreases the permeability of the system, improves overall resistance to CO_2 attack and enhances resistance to corrosion of steel in concrete. Highly micro porous structure RHA mixed concrete provides escape paths for the freezing water inside the concrete, relieving internal stresses, reducing micro cracking and improving freeze-thaw resistance.

2.1.2 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. This is mainly due to the large surface area of rice husk ash which is in the range of 50 to 60m²/g. Large additions would produce dry or unworkable mixtures unless water-reducing admixtures or superplastizers are used, 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. The addition of sand will significantly reduce the flow table spread.

2.1.3 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, 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.

2.1.4 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. 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. Pozzolanic reaction is a slow process and proceeds with time.

Rice husk ash adsorbs large amount of water due to its high specific surface area. This reduces bleeding water. 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.

2.1.5 THE MODULUS 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.

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. 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.

OTHER USES OF RICE HUSK ASH:-

Rice Husk Ash (RHA) acts as a very good insulator. Rice Husk Ash (RHA) is also used for insulation of molten metal in tundish and ladle in slab caster. The temperature of molten metal in the ladle is around 1400 degrees centigrade and above. When this metal flows from ladle to tundish, the temperature drops to around 1250 degrees. This reduction in temperature leads to choking and causes breakdown in the slab caster.

2.2 PUBLICATION REVIEW ON USE OF RICE HUSK ASH:-

2.2.1 STEEL INDUSTRY:-

RHA is used by the steel industry in the production of high quality flat steel. Flat steel is a plate product or a hot rolled strip product, typically used for automotive body panels and domestic 'white goods' products. This type of steel is generally produced by continuous casting, which has replaced the older ingot method. In the ingot method

molten steel was poured into a large mould where it would be allowed to cool and solidify to form an ingot. The ingot would then be rolled in primary mills, in the first stage of its transformation into a usable steel product.

It is in continuous casting that RHA plays a role. RHA is an excellent insulator, having low thermal conductivity, high melting point, low bulk density and high porosity. It is this insulating property that makes it an excellent 'tundish powder'. These are powders that are used to insulate the tundish, prevent rapid cooling of the steel and ensure uniform solidification. Traditionally ash is sold in bags which are thrown on to the top of the surface of the tundish of molten steel.

Approximately 0.5 to 0.7 kg of RHA is used per ton of steel produced. There are health issues associated with the use of RHA in the steel industry. Traditionally crystalline ash is preferred to amorphous. This poses problems as the ash has a tendency to explode over the operator when it is being thrown on top of the tundish, exposing them to crystalline silica and possible silicosis. A new innovation is the production of pellets from RHA which can be much better controlled, and are better from an operational and safety point of view.

Although RHA is an excellent insulator, it will oxidize with elements in steel such as aluminum to form alumina (Al_2O_3). This is a non-metallic compound that remains in the steel and is a nuisance in future use. Despite this it is still used in the production of certain steel where its insulating properties are necessary.

2.2.2 CEMENT AND CONCRETE INDUSTRY:-

Substantial research has been carried out on the use of amorphous silica in the manufacture of concrete. There are two areas for which RHA is used, in the manufacture of low cost building blocks and in the production of high quality cement.

Concrete is produced by mixing Portland cement with fine aggregate (sand), coarse aggregate (gravel or crushed stone) and water. Approximately 11% of ready mix concrete is Portland cement. It is the binding agent that holds sand and other aggregates together in a hard, stone-like mass. Cement is made by heating limestone and other ingredients to

1450°C in a kiln to produce clinker; this involves the dissociation of calcium carbonate under heat, resulting in lime (calcium hydroxide) and CO₂. The lime then combines with other materials to form clinker, while the CO₂ is released to the environment. The pulverized/ground clinker mixed with gypsum is called Portland cement. Portland cement produces an excess of lime. Adding a pozzolan, such as RHA, this combines with lime in the presence of water, results in a stable and more amorphous hydrate (calcium silicate). This is stronger, less permeable and more resistant to chemical attack. A wide variety of environmental circumstances such as reactive aggregate, high sulphate soils, freeze-thaw conditions, and exposure to salt water, de-icing chemicals, and acids are deleterious to concrete. Laboratory research and field experience has shown that careful use of pozzolans is useful in countering all of these problems. The pozzolan is not just a "filler", but a strength and performance enhancing additive. Pulverized fly ash and ground granulated blast furnace slag are the most common pozzolan materials for concrete. Many studies have been carried out to determine the efficacy of RHA as a pozzolan. They have concentrated on the quantity of ash in the mix and the improved characteristics resulting from its use.

2.2.3 LOW COST BUILDING BLOCKS:-

Ordinary Portland cement (OPC) is expensive and unaffordable to a large portion of the world's population. Since OPC is typically the most expensive constituent of concrete, the replacement of a proportion of it with RHA offers improved concrete affordability, particularly for low-cost housing in developing countries. The potential for good but inexpensive housing in developing countries is especially great. Studies have been carried out all over the world, such as in Guyana, Kenya and Indonesia on the use of low cost building blocks.

Higher strength concrete with Rice Husk Ash allows lighter weight products to be produced, such as hollow blocks with enhanced thermal insulation properties, which provide lighter walls for steel framed buildings. It also leads to reduced quantities of cement and aggregate.

2.2.4 OTHER USES:-

There are other uses for RHA which are still in the research stages:

1. In the manufacture of roof tiles.
2. As a free running agent for fire extinguishing powder.
3. Abrasive filler for tooth paste.
4. A component of fire proof material and insulation.
5. As a beer clarifier.
6. Extender filler for paint.
7. Production of sodium silicate films.

2.3 TECHNICAL REVIEW ON USE OF RICE HUSK ASH:-

2.3.1 INTRODUCTION:-

Commercially, it is important to determine and control the type and quality of rice husk ash produced. These can vary depending upon the different combustion techniques used. For example, stoker fired boilers tend to produce higher quantities of crystalline ash, whereas similar boilers with suspension firing produce more amorphous ash. The additional revenue stream provided by the sale of RHA may be the key to an energy projects' viability. If this is the case the appropriate technology should be chosen to produce ash of the required type and quality for the target RHA market. For example, the color of the ash is important for some cement markets where the ash influences the color of the final cementitious product, as well as being a major indicator of the samples' residual carbon.



Figure 3: Rice husk piles being

2.3.2 OVERVIEW OF HUSK TO ASH PROCESS:-

The husk surrounding the kernel of rice accounts for approximately 20% by weight of the harvested grain (paddy). The exterior of rice husks are composed of dentate rectangular elements, which themselves are composed mostly of silica coated with a thick cuticle and surface hairs. The mid region and inner epidermis contains little silica. In small single stage mills in developing countries, where bran (the layer within the husk) is not fully separated from the husk, the husk plus bran stream can rise to 25% of the paddy. For larger mills, where the husk and bran are fully separated (the type more likely to be providing the husk for electrical generation), a husk to paddy ratio of 20% is appropriate. Most heating values for rice husk fall in the range 12.5 to 14MJ/kg, lower heating value (LHV). If some bran remains with the husk, a somewhat higher calorific value results. Rice husks have low moisture content, generally in the range of 8% to 10%.

The high ash content of rice husks and the characteristics of the ash impose restrictions on the design of the combustion systems. For example, the ash

removal system must be able to remove the ash without affecting the combustion characteristics of the furnace (especially if the ash produced is mostly bottom ash). The temperatures must be controlled such that the ash melting temperature of approximately 1440°C is not exceeded and care must be taken that entrained ash does not erode components of the boiler tubes and heat exchangers.

2.3.3 OVERVIEW OF ASH PRODUCTION:-

The different types of combustion have one common characteristic. They all result in the oxidation of most of the “combustible” portion of the husk while leaving the inert portion. The inert portion is generally called ash or, after gasification, char. The distinction is somewhat blurred. Originally the term “char” referred to the uncombusted residue that had not been taken to a sufficiently high enough temperature to change its state, whereas the term “ash” implied that a higher temperature and change of state had occurred. However, when applied to RHA, the term ash appears to be reserved for all processes apart from gasification irrespective of whether a change of state has occurred. In chemical analyses of husks the term “ash” refers to the chemical constituents of the

Residual from complete combustion without consideration of the morphology of the components. The term “ash”, in this study refers to the residual of the particular combustion or gasification process which produced the ash. The fine particulate matter which is carried away from the combustion zone by the flue gas produces fly ash. With stoker and suspension fired boilers this ash is close to 100% amorphous since the crystalline portion of the ash does not seem to carry in the flue gas. Bottom ash is denser than fly ash, and for rice husks tends to be more crystalline than the fly ash.

The proportion of bottom ash to fly ash depends upon the boiler type and operating conditions.

2.3.4 METHODS OF ASH ANALYSIS:-

Typically, the ash will contain some un-burnt components as well as inert components of the husks. The un-burnt component is predominantly carbon. It is typically measured by reheating a sample of the ash in an oven. The difference in mass of

the sample before and after heating is referred to as the 'Loss on Ignition' (LOI). The LOI value is normally the same as the carbon content of the ash. The carbon content of RHA varies according to the combustion process. RHA analyses from a literature search and from analyses performed on RHA material for this study indicate carbon (or LOI) values ranging from 1% to 35%. Typically, commercial RHA combustion appears to result in RHA with 5-7% maximum carbon.

For RHA as a potentially marketable product we need only distinguish between amorphous silica and crystalline silica. Lechatelierite (silica glass), an amorphous form, and cristobalite, a crystalline form. SiO₂ can also occur in a very fine, submicron form. This form is of the highest commercial value although it is the most difficult to extract. The major and trace elements are conventionally expressed as their respective percentage oxides and may not actually be present in this oxide form. SiO₂ is generally determined as 'total' SiO₂, since the proportion of crystalline to amorphous silica requires further costly analysis, usually by X-Ray Diffraction (XRD). Determining the quantity of these polymorphs is fundamental to investigating a market for the ash. The color of the ash generally reflects the completeness of the combustion process as well as the structural composition of the ash.

Generally, darker ashes exhibit higher carbon content (with the exception of those that may be darker due to soil chemistry/region). Lighter ashes have achieved higher carbon burnout, whilst those showing a pinkish tinge have higher crystalline (tridymite or cristobalite) content.

EXPERIMENTAL

PROGRAMME

3.1 GENERAL:

This chapter deals with the Mix design procedure adopted for Control concrete and the studies carried out on properties of various materials used throughout the Experimental work. Also the details of method of Casting and Testing of Specimens are explained.

3.2 MATERIALS:

Materials which are used to produce concrete are:

- | | |
|------------------|---------------|
| 1. Cement | 4. Admixtures |
| 2. Rice Husk Ash | 5. Fiber |
| 3. Aggregates | 6. Water |

3.2.1 CEMENT:

Cement used in the experimental work is *Ordinary Portland Cement of 53^{grade} (Ambuja)* conforming to *IS: 12269-1987*. The Chemical & Physical Properties of Ordinary Portland Cement as per IS: 12269-1987 is given in table below.

<u>TABLE 2: CHEMICAL PROPERTIES OF ORDINARY PORTLAND CEMENT</u>	
<u>PARTICULARS</u>	<u>REQUIREMENTS OF IS: 12269-1987</u>
Loss on ignition	Not more than 4%
Magnesia(% by mass)	Not more than 6%
Sulphuric anhydride (% by mass)	Not more than 3%
Insoluble Material (% by mass)	Not more than 2%

<u>TABLE 3:PHYSICAL PROPERTIES OF ORDINARY PORTLAND CEMENT</u>	
<u>PARTICULARS</u>	<u>REQUIREMENT OF IS: 12269-1987</u>
Fineness	
Setting Time (Minutes):	
• Initial	>30
• Final	<600
Soundness:	
• Le-Chatlier Expansion	10mm max
• Autoclave Expansion	0.8% min.
Compressive Strength(MPa):	
• 72 ± 1hr (3 days)	>27MPa
• 168 ± 2hr (7 days)	>37MPa
• 672 ± 4hr (28 days)	>53MPa

<u>TABLE 4:CEMENT FINENESS TESTING REPORT</u>				
<u>BRAND NAME:-AMBUJA OPC 53</u>				
-				
Sr. No.	WEIGHT OF SAMPLE IN GMS.	90 MICRONS SIEVE RETAINED IN GMS.	% RETAINED	AVERAGE %
1	200	5	2.5	2.75
2	200	6	3	

3.2.2 RICE HUSK ASH:

Rice Husk Ash used in the present experimental study was obtained from *N.K Enterprises Jharsuguda, Orissa*. Specifications, Physical Properties and Chemical Composition of this RHA as given by the Supplier are given in Table.

<u>TABLE 5: SPECIFICATION OF RICE HUSK ASH</u>	
Silica	88.64%
Humidity	1.87%
Mean Particle Size	25 μ
Color	Grey Black
Loss on Ignition	<6%

<u>TABLE 6: PHYSICAL PROPERTIES OF RICE HUSK ASH</u>	
Physical State	Solid-Non Hazardous
Appearance	Powder
Particle Size	25 μ – Mean
Color	Grey Black
Odour	Odourless
Specific Gravity	2.3
Bulk Density	0.58gm/cc

<u>TABLE 7:CHEMICAL PROPERTIES OF RICE HUSK ASH</u>	
Silica – SiO ₂	88.64
Al ₂ O ₃	1.23
Fe ₂ O ₃	1.19
Carbon	2.33
CaO	1.09
MgO	1.76
K ₂ O	1.98
Others	1.78

3.2.3 AGGREGATES:

Aggregates which are used in this Experimental work are confirming to **IS: 383 1970**. Aggregate will consist of naturally occurring (Crushed or Uncrushed) stones, gravel and sand or combination thereof. They are hard, strong, dense, durable, clear and free from veins and adherent vegetable matter and other deleterious substance. As far as possible, flaky, and elongated pieces are avoided.

Fine Aggregates as well as Coarse Aggregates both are used while manufacturing concrete.

3.2.3.1 FINE AGGREGATE:

Fine aggregate was purchased which satisfied the required properties of fine aggregate required for experimental work and the sand confirms to zone II as per the specifications of IS 383: 1970.

- a) Specific gravity = 2.68
- b) Fineness modulus = 3.20
- c) Water Absorption = 3.29
- d) DLBD = 1.81 kg/lit

3.2.3.2 COARSE AGGREGATE:

Crushed granite of 20 mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates confirms to the specifications of IS 383: 1970 for graded aggregates.

- a) Specific gravity for: CA-I=2.87, CA-II=2.88
- b) Fineness Modulus for: CA-I=6.13, CA-II=7.13
- c) Water Absorption for: CA-I=1.63%, CA-II=1.42%
- d) DLBD for: CA-I=1.48 kg/lit, CA-II=1.46 kg/lit

3.2.4 ADMIXTURE:

In this Experimental work *Mineral admixture Fly ash* Confirming to Grade I of **IS: 3182** is used as a partial replacement of Ordinary Portland Cement (OPC) and *Chemical admixture (Sikament SP5204NS)* Confirming to **IS-9103:1999** is used.

3.2.5 WATER:

Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that maybe deleterious to concrete. Potable water is used for mixing concrete.

<u>TABLE 10 : TEST REPORT OF WATER</u>			
SR. NO.	SOLIDS	MAX. PERMISSIBLE LIMITS	ACTUAL
1	CHLORIDES	2000 PPM FOR PCC 500 PPM FOR RCC	250 PPM
2	SULPHATES	400 PPM	200PPM
3	ACIDITY	50 PPM	40 PPM
4	ALKALINITY	250 PPM	210 PPM
5	PH VALUE	6 TO 8	7

3.3 MIX DESIGN:

Concrete mix design is the process of choosing suitable ingredient of concrete and determining their relative quantities with the object of producing as economically as possible concrete of certain minimum properties, notable workability, strength and durability.

In this Experimental Work Department of Environment (DOE) Method of Mix Design was used for manufacturing concrete. DOE method is standard British method of concrete mix design. While Road Note No. 4 or Grading Curve Method was specifically developed for concrete pavements, the DOE method is applicable to concrete for most purposes, including roads.

<u>TABLE 9 : MIX DESIGN FOR M/40 GRADE</u>		
Materials	1M ³	0.05M ³
Cement	400	20
Fly Ash	130	6.5
Rice Husk Ash	As require (replacement with fly ash or cement)	-
Crushed Sand	640	32
Coarse Aggregate-I	440	22
Coarse Aggregate-II	650	32.5
Water	182.4	9.12
Admixture (1%)	5.3	0.265

3.4 CASTING OF TEST SPECIMENS [AS PER IS: 516-1959]:-

3.4.1 CUBE MOULDS [AS PER IS: 516-1959]:-

The mould was of metal, preferably steel or cast iron, and stout enough to prevent distortion. It was constructed in such a manner as to facilitate the removal of the moulded specimen without damage, and was so machined that, when it is assembled ready for use, the dimensions and internal faces were accurate within the following limits:

The height of the mould and the distance between opposite faces was of the specified size $\pm 0.2\text{mm}$. The angle between adjacent internal faces and between internal faces and top and bottom planes of the mould was $90^0 \pm 0.5^0$. The interior faces of the mould were plane surfaces with a permissible variation of 0.03 mm . Each mould was provided with a metal base plate having a plane surface. The base plate was of such dimensions as to support the mould during the filling without leakage and it was preferably attached to the mould by spring or screws.

In assembling the mould for use, the joints between the sections of mould were thinly coated with mould oil and a similar coating of mould oil was applied between the contact surfaces of the bottom of the mould and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the assembled mould were thinly coated with mould oil to prevent adhesion of the concrete.

3.4.2 PREPARATION OF TEST MATERIALS:

The cement samples, on arrival at the laboratory, were thoroughly mixed dry in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material, care was been taken to avoid the intrusion of foreign matter.

Samples of aggregates for each batch of concrete were of the desired grading and in an air-dried condition. In general, the aggregates were separated into fine and coarse fraction and recombined for each concrete batch in such a manner as to produce the desired grading. IS sieve 480 was normally used for separating the fine and coarse fractions, but where special grading was been investigated, both fine and coarse fractions were further separated into different sizes.

3.4.3 WEIGHING:

The quantities of cement, each size of aggregate, and water for each batch was determined by weight, to an accuracy of 0.1 percent of the total weight of the batch.

3.4.4 MIXING:

The concrete was mixed in a Drum mixer, in such a manner as to avoid loss of water or other materials. Each batch of concrete was such a size as to leave about 10 percent excess after molding the desired number of test specimens.

3.5 COMPACTION OF TEST SPECIMENS [AS PER IS: 516-1959]:-

The test specimens were made as soon as practicable after mixing and in such a ways to produce full compaction of the concrete with neither segregation nor excessive laitance. The concrete was filled into the mould in layers approximately 5 cm deep.

In placing each scoopful of concrete, the scoop was moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete within the mould. Each layer was compacted either by hands described below. After the top layer had been compacted, the surface of the concrete was finished level with the top of the mould, using a trowel, and covered with a metal plate to prevent evaporation.

3.5.1 COMPACTION BY HAND:

When compacting by hand, the standard tamping bar was used and the strokes of the bar were distributed in a uniform manner over the cross section of the mould. The number of strokes per layer required to produce specified conditions varied according to the type of concrete. For cubical specimens, in no case the concrete was subjected to less than 35 strokes per layer for 15 cm cubes. The strokes penetrated into the underlying layer and the bottom layer was rodded throughout its depth. Where voids were left by tamping bar, the sides of the mould were tapped to close the voids.

3.6 CURING OF TEST SPECIMENS [AS PER IS: 516-1957]:

The test specimens was stored on the site at a place free from vibration, under damp matting, sacks or other similar material for 24 hours $\pm$ ½ hour from the time of adding the water to the other ingredients.

After the period of 24 hours, they were marked for later identification, removed from the Moulds and, unless required for testing within 24hours, stored in clean water at a temperature of 24°C to 30°C until they were transported to the testing laboratory.

On arrival at the testing laboratory, the specimens were stored in water at a temperature of $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ until the time of test. Records of the daily maximum and minimum temperature were kept both during the period of the specimens remained on the site and in the laboratory.

3.7 TEST FOR COMPRESSIVE STRENGTH OF CONCRETE SPECIMEN [AS PER IS: 516-1959]:

3.7.1 TESTING MACHINE:

The testing machine of reliable type, of sufficient capacity for the tests and capable of applying the load at the specified rate. The permissible error was not greater than ± 2 percent of the maximum load.

3.7.2 PROCEDURE:

Specimens stored in water were tested immediately on removal from the water and in the wet condition. Surface water and grit was wiped off the specimens and the projecting fins were removed. Specimens when received dry were kept in water for 24hours before they were taken for testing. The dimensions of the specimens to the nearest 0.2 mm and their weight were noted before testing.

The bearing surface of the testing machine was wiped clean and loose sand or other material removed from the surfaces of the specimen which were to be in contact with the compression platens. In the case of cubes, the specimen was placed in the

machine in such a manner that the load was applied to opposite sides of the cubes as cast, that is, not to the top and bottom.

The axis of the specimen was carefully aligned with the center of thrust of the spherically seated platen. No packing was used between the faces of the test specimen and the steel platen of the testing machine. As the spherically seated block is brought to bear on the specimen, the movable portion was rotated gently by hand so that uniform seating may be obtained.

The load was applied without shock and increased continuously at a rate of approximately 140 kg/sq. cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen was recorded and the appearance of the concrete and any unusual features in the type of failure was noted.

3.7.3 CALCULATION:

The measured compressive strength of the specimen was calculated by first converting the maximum load applied from [kg to N] and then dividing the load by the cross-sectional area [in sq.mm], of specimen calculated from the mean dimensions of the section and was expressed to the nearest N/sq.mm. Averages of three values were taken as the representative of the batch provided the individual variation not more than $\pm 15\%$ of the average.

RESULTS AND DISCUSSIONS

4.1 GENERAL:

This chapter deals with the presentation of test results, and discussions on Compressive and development of Control concrete and Rice husk ash concrete at different curing periods. The present investigation is based on the DOE method for Control concrete. For Rice husk ash (RHA) concrete, replacement method is considered. Trial mix proportions have been obtained for M40 grade Control concrete from the mix design. Compressive strength behavior of RHA concrete designed by the replacement method are studied, where in the effect of age and percentage replacement of cementitious material with RHA on Compressive strength is studied in comparison with that of M40 grade Control concrete.

4.2 MIX PROPORTIONING:

4.2.1 MIX PROPORTIONING OF CONTROL CONCRETE:

According to DOE method of mix design, the proportions of Control concrete were first obtained; trial mixes were carried out to determine the strength at 1, 3, 7, 28, 45 & 56 days, and the results obtained are shown in figure, where in the compressive strength obtained for M40 grade trial mixes are represented against age.

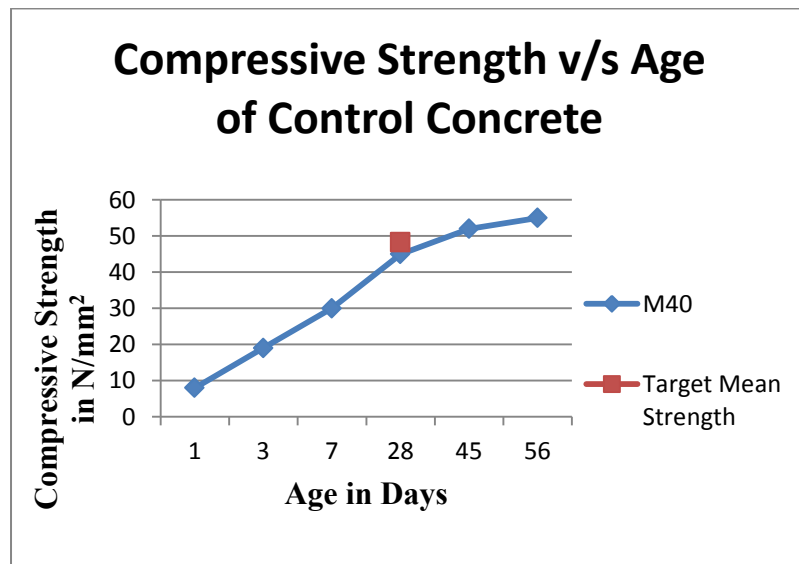


Figure 4: Compressive strength v/s Age of Control concrete

4.2.2 MIX PROPORTIONING OF RICE HUSK ASH (RHA) CONCRETE:

A) In this method, three replacements of Fly Ash i.e., 5%, 10%, and 15% with Rice husk ash (RHA) are done, whereas the total binder content remains the same. The mix proportions considered for each replacement by replacement method with RHA are presented in tables:

TABLE 10 : MIX PROPORTION OF RICE HUSK ASH CONCRETE FOR 5% REPLACEMENT

GRADE OF CONCRETE	CEMENT IN KGS	FLY ASH IN KGS	RICE HUSK ASH IN KGS	CRUSHED SAND	COARSE AGGREGATE CA- I	COARSE AGGREGATE CA- II	WATER IN LTRS	ADMIXT URE
M40 (0.05M³)	20	6.175	0.325	32.2	22	32	9.12	0.265
IN CUM	400	123.5	6.5	644	440	640	182.4	5.3

TABLE 11 : MIX PROPORTION OF RICE HUSK ASH CONCRETE FOR 10% REPLACEMENT

GRADE OF CONCRETE	CEMENT IN KGS	FLY ASH IN KGS	RICE HUSK ASH IN KGS	CRUSHED SAND	COARSE AGGREGATE CA- I	COARSE AGGREGATE CA- II	WATER IN LTRS	ADMIX TURE
M40 (0.05M³)	20	5.85	0.65	32.2	22	32	9.12	0.265
IN CUM	400	117	13	644	440	640	182.4	5.3

TABLE 12 : MIX PROPORTION OF RICE HUSK ASH CONCRETE FOR 15% REPLACEMENT

GRADE OF CONCRETE	CEMENT IN KGS	FLY ASH IN KGS	RICE HUSK ASH IN KGS	CRUSHED SAND	COARSE AGGREGATE CA- I	COARSE AGGREGATE CA- II	WATER IN LTRS	ADMIX TURE
M40 (0.05M³)	20	5.525	0.975	32.2	22	32	9.12	0.265
IN CUM	400	110.5	19.5	644	440	640	182.4	5.3

B) In this method, three replacements of Cement i.e., 5%, 10%, and 15% with Rice husk ash (RHA) are done, whereas the total binder content remains the same. The mix proportions considered for each replacement by replacement method with RHA are presented in tables:

TABLE 13 : MIX PROPORTION OF RICE HUSK ASH CONCRETE FOR 5% REPLACEMENT

GRADE OF CONCRETE	CEMENT IN KGS	FLY ASH IN KGS	RICE HUSK ASH IN KGS	CRUSHED SAND	COARSE AGGREGATE CA- I	COARSE AGGREGATE CA- II	WATER IN LTRS	ADMIX TURE
M40 (0.05M ³)	19.675	6.5	0.325	32.2	22	32	9.12	0.265
IN CUM	393.5	130	6.5	644	440	640	182.4	5.3

TABLE 14 : MIX PROPORTION OF RICE HUSK ASH CONCRETE FOR 10% REPLACEMENT

GRADE OF CONCRETE	CEMENT IN KGS	FLY ASH IN KGS	RICE HUSK ASH IN KGS	CRUSHED SAND	COARSE AGGREGATE CA- I	COARSE AGGREGATE CA- II	WATER IN LTRS	ADMIX TURE
M40 (0.05M ³)	19.35	6.5	0.650	32.2	22	32	9.12	0.265
IN CUM	387	130	13	644	440	640	182.4	5.3

TABLE 15 : MIX PROPORTION OF RICE HUSK ASH CONCRETE FOR 15% REPLACEMENT

GRADE OF CONCRETE	CEMENT IN KGS	FLY ASH IN KGS	RICE HUSK ASH IN KGS	CRUSHED SAND	COARSE AGGREGATE CA- I	COARSE AGGREGATE CA- II	WATER IN LTRS	ADMIX TURE
M40 (0.05M ³)	19.025	6.5	0.975	32.2	22	32	9.12	0.265
IN CUM	380.5	130	19.5	644	440	640	182.4	5.3

4.3 COMPRESSIVE STRENGTH:

Most concrete structures are designed assuming that concrete possesses sufficient compressive strength but not the tensile strength. The compressive strength is the main criterion for the purpose of structural design. To study the strength development of Rice husk ash (RHA) concrete in comparison to Control concrete, compressive strength tests were conducted at the ages of 1, 3, 7, 28, 45 and 56 days. The test results are reported in table for control concrete and in table for RHA concrete respectively.

4.3.1 CONTROL CONCRETE (CC):

a) Effect of Age on Compressive Strength: Table 16 gives the test results of Control concrete. The 28 days strength obtained for M40 grade Control concrete is 45MPa. The strength results reported in table 16 are presented in the form of graphical variation figure 4 where the compressive strength is plotted against the curing period.

<u>TABLE 16 : COMPRESSIVE STRENGTH OF CONTROL CONCRETE IN N/MM²</u>						
GRADE OF CONCRETE	1 DAY	3 DAYS	7 DAYS	28 DAYS	45 DAYS	56 DAYS
M40	8	19	30	45	52	55

From the table, it is clear that as the age advances, the strength of Control concrete increases. The rate of increase of strength is higher at curing period up to 28 days. However the strength gain continues at a slower rate after 28 days.

Strength achieved by M40 grade control concrete at different ages as a ratio of strength at 28 days is reported in table 17. From the table, it can be seen that 1 days strength is found to be 0.178 times that of 28 days strength, for 3 days, the strength is found to be 0.422 times that of 28 days strength, for 7 days, the strength is found to be 0.667 times that of 28 days strength, for 45 days, the strength is found to be 1.156 times that of 28 days strength, & for 56 days, the strength is found to be 1.222 times that of 28 days strength.

TABLE 17: COMPRESSIVE STRENGTH AS A RATIO OF 28 DAYS STRENGTH AT DIFFERENT AGES FOR CONTROL CONCRETE

GRADE OF CONCRETE	1 DAY	3 DAYS	7 DAYS	28 DAYS	45 DAYS	56 DAYS
M40	0.178	0.422	0.667	1	1.156	1.222

4.3.2 RICE HUSK ASH (RHA) CONCRETE:

a) Effect of age on Compressive Strength of Concrete: Figure 5 to figure 6 represents the variation of compressive strength with age for M40 grade RHA concrete, in each figure, variation of compressive strength with age is depicted separately for each replacement level of RHA considered namely 5%, 10%, and 15%. Along with the variations shown for each replacement, for comparison a similar variation is also shown for control concrete i.e., for 0% replacement. In each of these variations, it can be clearly seen that, as the age advances, the compressive strength also increases.

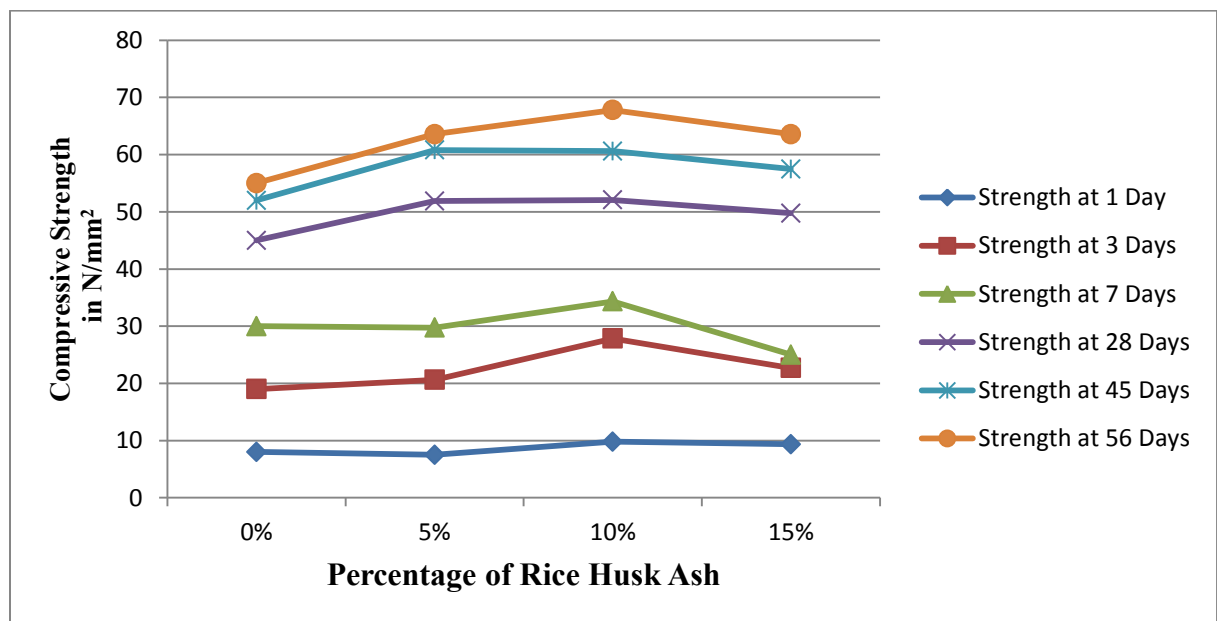


Figure 5: Effect of Rice Husk Ash percentage on compressive strength of concrete

(Fly Ash replaced with RHA)

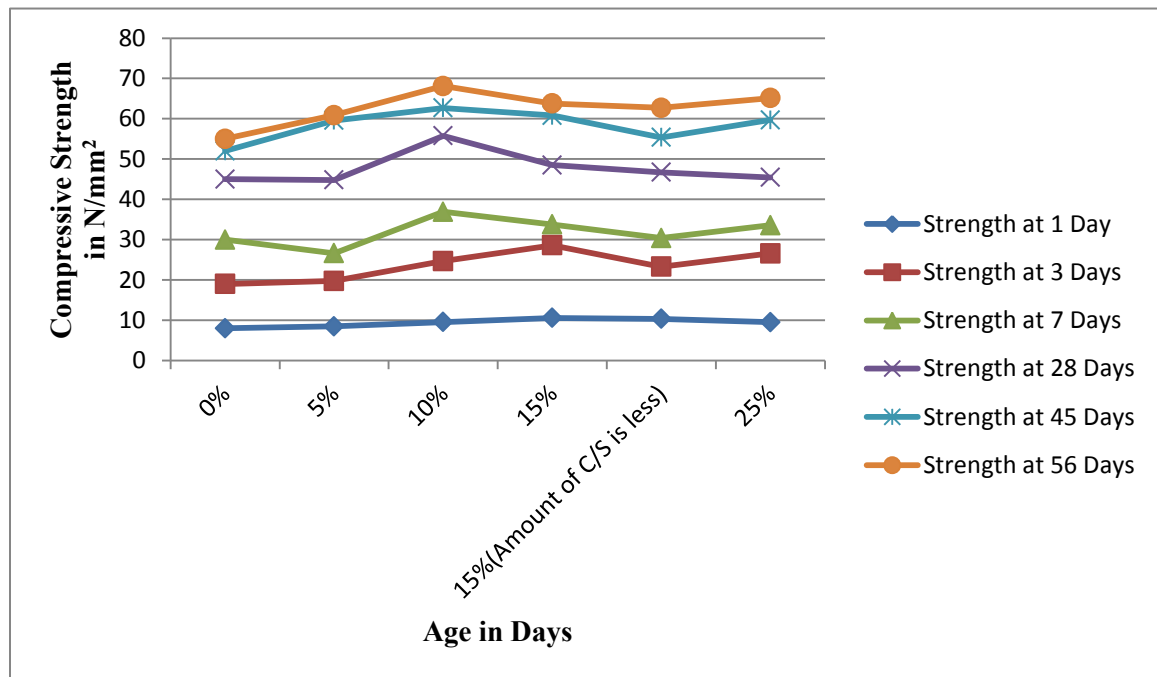


Figure 6: Effect of Rice Husk Ash percentage on compressive strength of concrete
(Cement replaced with RHA)

<u>TABLE 18 : HIGHEST COMPRESSIVE STRENGTH OBTAINED AT DIFFERENT AGES</u> <u>(FLY ASH REPLACED WITH RHA)</u>				
AGE IN DAYS	0%	5%	10%	15%
1	8	7.5	9.79	9.35
3	19	20.64	27.86	22.69
7	30	29.74	34.33	25.03
28	45	51.88	52.07	49.74
45	52	60.81	60.69	57.46
56	55	63.56	67.78	63.58

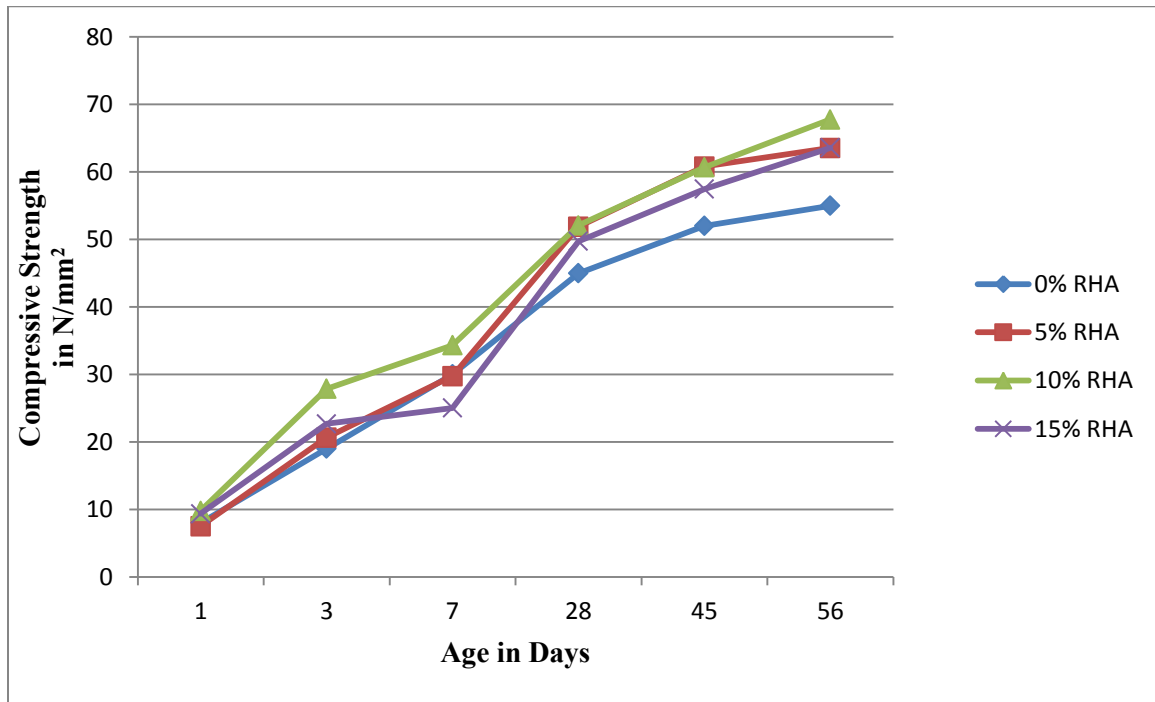


Figure 7: Effect of age on compressive strength of concrete w.r.t different % of Fly Ash replaced by Rice Husk Ash

<u>TABLE 19 : HIGHEST COMPRESSIVE STRENGTH OBTAINED AT DIFFERENT AGES</u> <u>(CEMENT REPLACED WITH RHA)</u>						
AGE IN DAYS	0%	5%	10%	15%	15%(C/SAND 50KG LESS)	25%
1	8	8.5	9.55	10.6	9.31	9.5
3	19	19.76	24.68	28.63	23.28	26.6
7	30	26.62	36.89	33.78	30.4	33.56
28	45	44.81	55.78	48.62	46.73	45.43
45	52	59.58	62.67	60.8	55.36	59.7
56	55	60.9	68.1	63.8	62.7	65.13

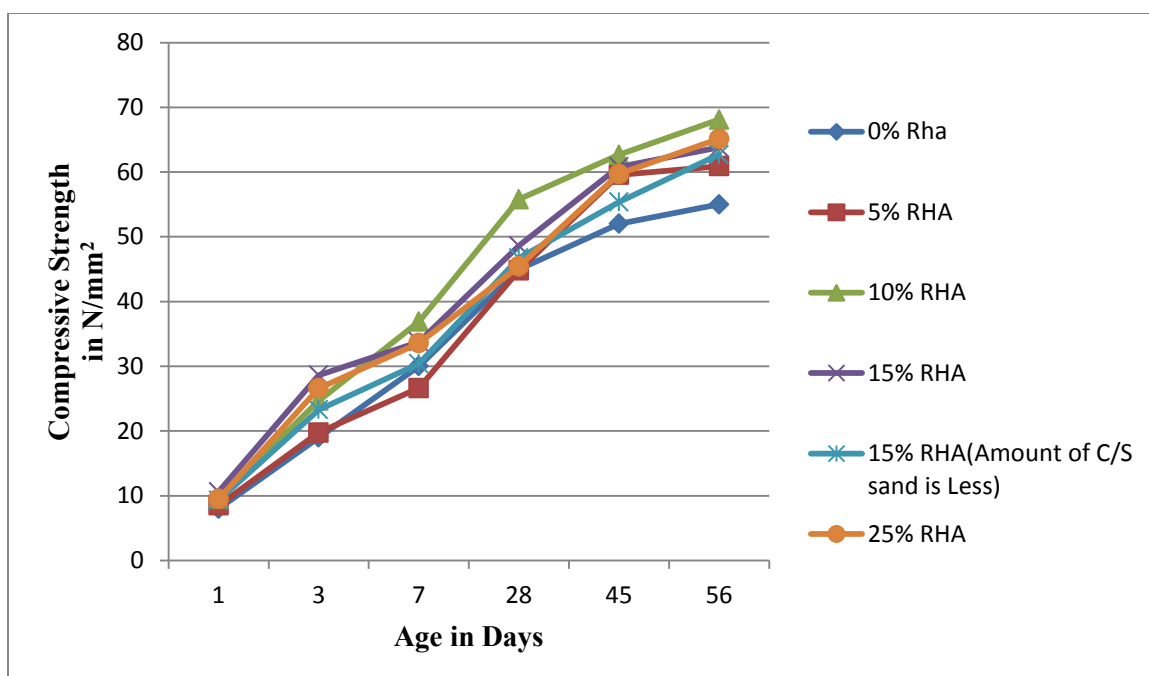


Figure 8: Effect of age on compressive strength of concrete w.r.t different % of Cement replaced by Rice husk Ash

REPLACEMENT OF FLY ASH WITH RICE HUSK ASH:-

TABLE 20: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 1 DAY W.R.T % REPLACEMENT OF RHA

PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	-6.25
10%	+22.375
15%	+16.875

TABLE 21: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 3 DAYS W.R.T % REPLACEMENT OF RHA

PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	+8.63
10%	+46.63
15%	+19.42

TABLE 22: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 7 DAYS W.R.T %**REPLACEMENT OF RHA**

PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	-0.867
10%	+14.43
15%	-16.567

TABLE 23: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 28 DAYS W.R.T**% REPLACEMENT OF RHA**

PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	+15.289
10%	+15.711
15%	+10.533

TABLE 24: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 45 DAYS W.R.T**% REPLACEMENT OF RHA**

PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	+16.942
10%	+16.711
15%	+10.5

TABLE 25: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 56 DAYS W.R.T**% REPLACEMENT OF RHA**

PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	+15.564
10%	+23.236
15%	+15.6

REPLACEMENT OF CEMENT WITH RICE HUSK ASH:-

TABLE 26: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 1 DAY W.R.T %

<u>REPLACEMENT OF RHA</u>	
PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	+6.25
10%	+19.375
15%	+32.5
15% (Amount of C/S is Less)	+16.375

TABLE 27: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 3 DAYS W.R.T

<u>% REPLACEMENT OF RHA</u>	
PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	+4.00
10%	+29.895
15%	+50.684
15% (Amount of C/S is Less)	+22.526

TABLE 28: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 7 DAYS W.R.T

<u>% REPLACEMENT OF RHA</u>	
PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	-11.267
10%	+22.967
15%	+12.6
15% (Amount of C/S is Less)	+1.33

TABLE 29: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 28 DAYS W.R.T**% REPLACEMENT OF RHA**

PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	-0.422
10%	+23.956
15%	+8.044
15% (Amount of C/S is Less)	+3.844

TABLE 30: INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 45 DAYS W.R.T**% REPLACEMENT OF RHA**

PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	+14.577
10%	+20.519
15%	+16.923
15% (Amount of C/S is Less)	+6.462

TABLE 31 : INCREASE OR DECREASE IN STRENGTH OF CONCRETE AT 56 DAYS W.R.T**% REPLACEMENT OF RHA**

PERCENTAGE REPLACEMENT	INCREASE OR DECREASE IN STRENGTH (IN %)
5%	+10.727
10%	+23.818
15%	+16
15% (Amount of C/S is Less)	+14

FUTURE SCOPE

- ❖ Other levels of replacement with Rice husk ash can be researched.
- ❖ The RHA mixed concrete can be tested with various Non- destructive testing methods, after some years, which will help determine the actual life of concrete for the mix proportions.
- ❖ Some tests relating to durability aspects such as water permeability, resistance to penetration of chloride ions, corrosion of steel reinforcement, resistance to Sulphates attack durability in marine environment etc. with Rice husk ash and Silica fumes need investigation.
- ❖ The study may further be extended to know the behavior of concrete whether it is suitable for pumping purpose or not as present day technology is involved in RMC, where pumping of concrete is being done to large heights.
- ❖ For use of Rice husk ash concrete as a structural material, it is necessary to investigate the behavior of reinforced Rice husk ash concrete under flexure, shear, torsion and compression.
- ❖ The additional absorbed water in the porous RHA particles can be calculated and this is very important in designing concrete mixtures containing RHA.
- ❖ Combinations of RHA with other admixtures in concrete and study of reactions between them can be further done.
- ❖ Behavior of RHA concrete for various exposure conditions like Coastal regions, underground, alkaline, mass concreting, etc. Can be studied.
- ❖ Compatibility and effects of use of RHA with types of cements like Rapid hardening cement, low heat cement, Sulphates resisting cement, oil well cement etc. Which are other than the Portland cement can be studied.

- ❖ The relative characteristic tensile strength of the RHA concrete can be determined.
- ❖ The Strength of RHA for different mix proportions and water-cement ratios can be determined.

CONCLUSION

Based on the Experimental study carried out on the use of Rice Husk ash in Concrete, following conclusions are drawn:

- ❖ At all the cement replacement levels of Rice husk ash, the rate of development of compressive strength up to 28 days is slower as compared with that of concrete in which RHA content is zero, while the rate of development of strength gradually increases after 28 days up to 56 days in case of RHA mixed concrete.
- ❖ The compressive strength of concrete having 10% replacement was found to be more than the other levels of replacements. (i.e. 0%, 5%, & 15%).
- ❖ For the desired workability and strength, the water content required in case of RHA mixed concrete was more than in normal concrete. This is because RHA is finer than cement & the fact is that RHA particles being finer it has more surface area and hence water required is comparatively more.
- ❖ The addition of RHA increases the degree of hydration of cement at the later period. This positive effect of RHA on the hydration of cement is possibly attributed to the pozzolanic reaction and the absorbed water in the porous structure of RHA. Thus, such a concrete is very useful in conditions of hot weather & in Mass concreting.
- ❖ By using this Rice husk ash in concrete as replacement the emission of greenhouse gases can be decreased to a greater extent. As a result there is greater possibility to gain more number of carbon credits.
- ❖ The technical and economic advantages of incorporating Rice Husk Ash in concrete should be exploited by the construction and rice industries.

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GLIMPSE OF SITE



RMC PLANT



SIEVE SHAKER AND WEIGHING MACHINE



SLUMP CONE TEST APPARATUS



DIGITAL COMPRESSION TESTING MACHINE



CUBE MOULDS



CONCRETE DRUM MIXER